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FLUORIDE EMISSIONS FROM PHOSPHORIC ACID PLANT GYPSUM PONDS

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North Carolina State University
Raleigh, North Carolina

October 1974

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16. ABSTRACT

The report gives results of a study of fluoride emissions from ponds receiving process water from wet-process phosphoric acid plants. Volatile fluorine compounds accumulate in water used in the manufacture of phosphoric acid by the wet-process method. This process water is routed to ponds for cooling and eventual re-use. While in the ponds, some of the fluorine compounds evaporate, becoming air pollutants. In this study, emission estimates were developed from the pond-to-air mass transfer coefficient and the vapor pressure of fluorine over pond water. These estimates were tested by measurements of ambient-air, fluorine-compound concentrations downwind of the ponds. Comparing the measured ambient air concentrations with concentrations predicted from the emission estimates and a standard atmospheric pollutant dispersion model demonstrated the validity of the emission estimates.

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by

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TABLE OF CONTENTS

Page

1. INTRODUCTION 1

2. METHOD OF APPROACH 4

3. RESULTS 9

4. MASS TRANSFER COEFFICIENT 14

 4.1 Introduction 14
 4.2 Model Development 15
 4.3 Data Base for the Water Mass Transfer Coefficient . 19
 4.4 Water Mass Transfer Coefficient Development 24
 4.5 Discussion of Results 28
 4.6 Comparison of Correlation Against Other Available Data 30
 4.7 Previous Correlations 32
 4.8 Fluorine Mass Transfer Coefficient Development . . . 39

5. WIND SPEED PROFILE 42

 5.1 Introduction 42
 5.2 Model Development 42
 5.3 Data Base 45
 5.4 Wind Speed Profile Exponent 46
 5.5 Discussion of Velocity Profile Exponent 46

6. FLUORINE ANALYTICAL METHODS 51

7. VAPOR LIQUID EQUILIBRIUM FOR THE POND WATER-FLUORINE SYSTEM. 52

 7.1 Literature Review 52
 7.2 Experimental Results and Discussion 53
 7.3 Vapor-Liquid Equilibrium Still 69

  7.3.1 Design, Operation and Accuracy 69
  7.3.2 Demonstration of the Still's Capability to Produce Thermodynamically Consistent Data 75

8. AMBIENT AIR MEASUREMENTS 76

 8.1 Summary 76
 8.2 Data Collected 76
 8.3 Pond Descriptions 77

TABLE OF CONTENTS (Continued)

Page

8.3.1 Pond 10 77
8.3.2 Pond 20 80

8.4 Sampler, Sample Recovery and Sample Analysis 84

9. COMPUTER SIMULATION OF POND EMISSIONS AND AMBIENT AIR CONCENTRATIONS 87

9.1 Simulation Concepts 87
9.2 Data Inputs 89
9.3 Output of the Simulation 89

10. VERIFICATION OF THE POND SIMULATION 96

10.1 Verification 96
10.2 Background Concentrations 101
10.3 Conclusions 103

11. EMISSION ESTIMATES 104

11.1 This Study 104
11.2 Other Studies 105

12. FUTURE WORK 108

12.1 Extensions 108
12.2 Offshoots 109

13. NOMENCLATURE 111

14. LIST OF REFERENCES 116

15. APPENDIX 119

15.1 Discussion of Partial Pressure Assumptions in Mass Transfer Development 120
15.2 Analytical Procedure 124

15.2.1 Equipment 124
15.2.2 Procedure 125
15.2.3 Sample Problem 126

15.3 Vapor-Liquid Equilibrium for the System $HF-H_2O$ . . . 126

15.3.1 Introduction 126
15.3.2 Existing Data Correlations 127

TABLE OF CONTENTS (Continued)

Page

15.3.2.1 Correlating equations 127
15.3.2.2 Correlations 131

15.3.3 Comparison of this Study's Results with $HF-H_2O$ Correlations 135

15.4 Usable Ambient Air Fluorine Concentration Measurements 142

15.4.1 Pond 10 Downwind 142
15.4.2 Pond 20 Downwind 194
15.4.3 Pond 10 Upwind Sampler - 03 232

15.5 Unusable Ambient Air Fluorine Concentration Measurements 239

15.5.1 Pond 10 239
15.5.2 Pond 10 249
15.5.3 Pond 20 257
15.5.4 Pond 20 275

15.6 Sampler Studies 286

15.6.1 Sampler Efficiency 286
15.6.2 Ambient Air Sampling Procedure 288

15.6.2.1 Equipment 288
15.6.2.2 Procedure 288

15.6.3 Sample Recovery Procedure 290

15.7 Pond Simulation Program 291
15.8 Calculation of Fluorine Vapor Pressure 316

1. INTRODUCTION

One of the major operations in the production of phosphate fertilizers and chemicals is the processing of phosphate ore by the wet-process to phosphoric acid. The major step in this synthesis is the reaction of the ore with sulfuric acid. A complete description of the wet-process is given in [14].

The ore consists mainly of mixtures of the mineral fluorapatite ($3\ Ca_3(PO_4)_2 \cdot CaF_2$) and partially substituted homologs such as hydroxy-apatite ($3Ca_3(PO_4)_2 \cdot Ca(OH)_2$). The ore contains approximately 3.5 percent fluorine, part of which reacts during processing to form volatile, water-soluble compounds. The aqueous streams carrying these fluorine compounds are discharged into one or more ponds for cooling, storage, reconditioning and eventual reuse. Figure 1.1 is a simplified flow sheet for a 1,000 ton per stream day (as P_2O_5) wet-process phosphoric acid plant with the fluorine material balance shown. Over 85% of the fluorine entering the plant accumulates in the pond system.

Phosphate ores containing 4.78 million tons of P_2O_5 were converted by the wet-process into phosphoric acid in 1971 [20]. The apparent production growth rate between 1968 and 1971 was 14.5 percent per year [19, 20]. In 1969, wet-process plants were reported to be operating in 38 separate locations [8, pg. 7-17]. Pond sizes, based on limited observations, appear to vary from one tenth to four tenths acres per daily ton of acid capacity expressed as P_2O_5. If all ponds fall in this range, between 1500 and 5800 acres of ponds existed in connection with wet-process plants in 1971.

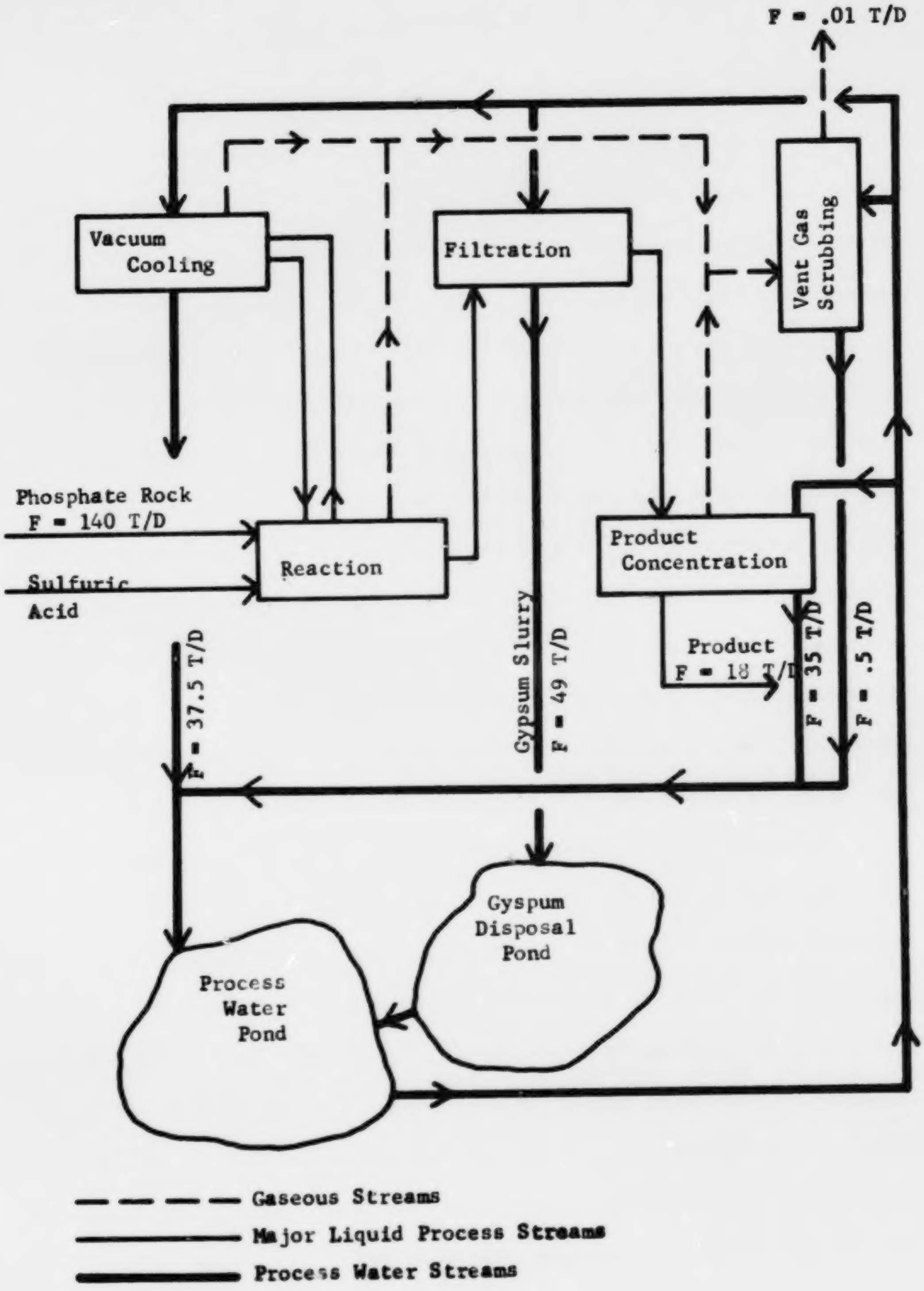

F = .01 T/D
Vacuum Cooling
Filtration
Vent Gas Scrubbing
Phosphate Rock F = 140 T/D
Sulfuric Acid
Reaction
Product Concentration
Product F = 18 T/D
F = 35 T/D
F = .5 T/D
Gypsum Slurry F = 49 T/D
F = 37.5 T/D
Gyspum Disposal Pond
Process Water Pond
Gaseous Streams
Major Liquid Process Streams
Process Water Streams

Figure 1.1 Block flow diagram and flucride balance for 1000 T/Stream Day Wet Process Phosphoric Acid Plant [8, pp. 3-45 to 3-150]

The literature contains estimates of fluorine emissions from the ponds that range from 0.2 to over 10 pounds of fluorine per acre day; however, the data base for these estimates is too fragmentary to allow the best estimate to be identified. Even so, simple calculations show that the ponds are potentially a very large and uncontrolled source of fluorine emission to the atmosphere.

The objective of this study was to develop a sound engineering method for estimating the fluorine emissions from these ponds, and to test the method experimentally for ponds in existing wet-process plants in two separate locations. The magnitude of the emission control problem could then be documented.

2. METHOD OF APPROACH

All wet-process plants surveyed used one or more ponds for process water cooling and for disposal of by-product gypsum. Since all ponds within a single plant are interconnected and have essentially the same fluorine concentration, they can be evaluated as a single unit. In this study the term pond will refer to the entire system for a single plant.

The volatile fluorine-containing chemical species were not identified in this study; all mass fluxes, concentrations, and partial pressures involving fluorine compounds are reported as elemental fluorine (F) . In the past it has usually been assumed without proof that the volatile compounds are hydrogen fluoride (HF) and silicon tetrafluoride (SiF_4) in the gaseous phase, and hydrofluosilicic acid (H_2SiF_6) in the liquid phase.

Ponds are large, diffuse emission sources and it is very difficult, if not impossible, to measure fluorine emissions directly; therefore direct measurements were not attempted in this project. An alternate approach was taken whereby fluorine emission rates were estimated from a knowledge of the fluorine concentration and water temperature in the pond and atmospheric conditions at the pond. These predictions were then verified by measurements of ambient air fluorine concentration downwind from the pond.

The overall approach can be divided into two steps: prediction of emission rate and verification by downwind ambient measurement. The first step, the prediction of the emission rate can best be described by reference to the general equation for mass transfer of fluorine from the pond water to the atmosphere

$$N_F = K_F(p_F^* - p_F) \tag{1}$$

where

N_F = fluorine transfer rate per unit surface area from pond to atmosphere,

K_F = overall gas-side fluorine mass transfer coefficient,

P_F^* = partial pressure of fluorine in equilibrium with pond water, and

P_F = partial pressure of fluorine in atmosphere above pond.

The specific tasks in this step are:

1) Measurement of the equilibrium vapor pressure (P_F^*) of fluorine over samples of pond water,
2) Development of a correlation for predicting the mass transfer coefficient (K_F) from existing data, and
3) Prediction of fluorine mass transfer rates by Equation (1) (N_F) .

The second step in the overall approach is the verification of the emission estimates. The specific tasks in this step are:

1) Development of a computer simulation of fluorine transfer from ponds using Equation (1) and the atmospheric dispersion of the fluorine downwind of the pond,
2) Prediction of the fluorine concentration in the atmosphere downwind of the pond by use of the computer simulation model,
3) Measurement of fluorine emission rates downwind of the ponds, and
4) Comparison of measured and predicted downwind concentrations and verification of the computer simulation and its component parts, including the emission prediction method.

For reasons discussed in Chapter 3, calculation of experimental emissions from the experimental ambient air measurements would be unsound; therefore, measured and calculated ambient air fluorine concentrations were compared to demonstrate the validity of the method of estimating fluorine emissions. The good agreement between predicted and measured fluorine concentrations in the atmosphere downwind of two ponds, shown in Chapter 10, verifies the computer simulation of the pond emissions and of the atmospheric dispersion of fluorine. Since the pond fluorine emission estimate is an important part of the simulation, the agreement between predicted and measured ambient air concentrations also verifies the method of predicting emissions from ponds developed in this report.

The approach described in this chapter can be used for any pond and should also be sufficiently general to apply to the emission of other pollutants from both natural ponds and waste disposal ponds.

The steps outlined above are discussed in detail in the chapters that follow. Figure 2.1 is a work flow sheet showing in more detail the various steps in the study and their interrelations.

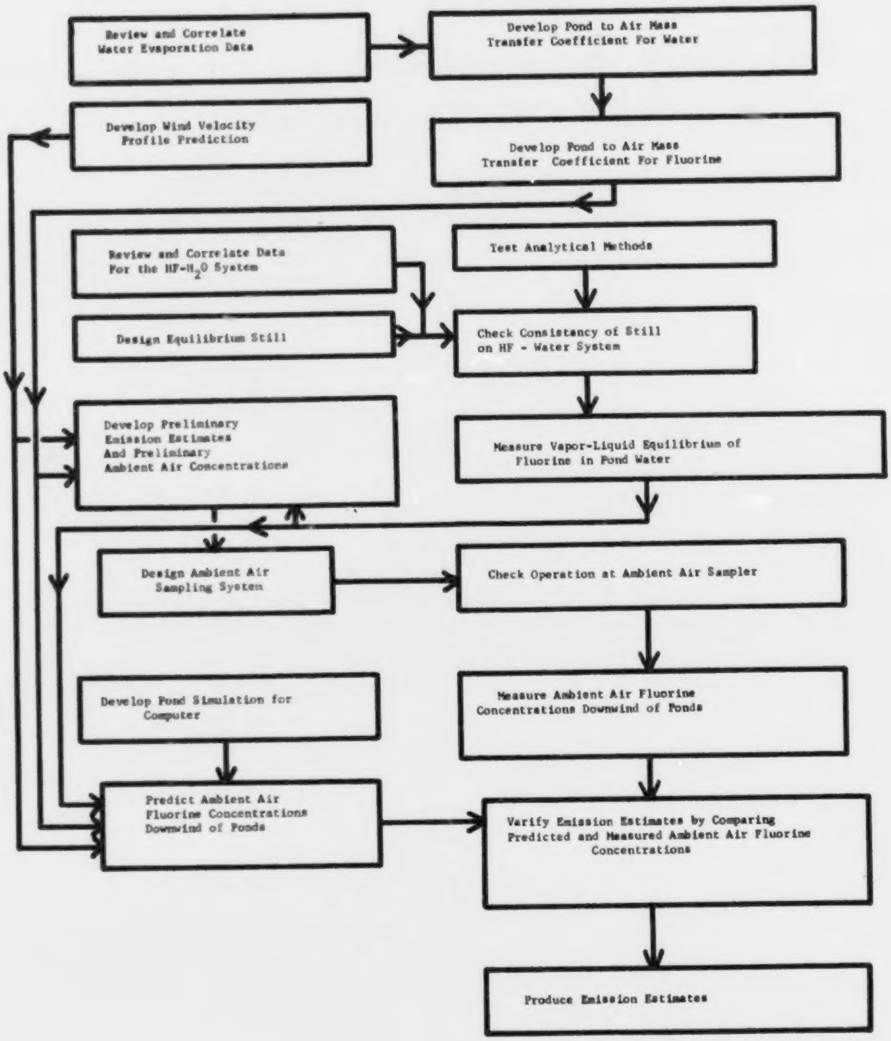

Review and Correlate Water Evaporation Data
Develop Pond to Air Mass Transfer Coefficient For Water
Develop Wind Velocity Profile Prediction
Develop Pond to Air Mass Transfer Coefficient For Fluorine
Review and Correlate Data For the HF-H2O System
Test Analytical Methods
Design Equilibrium Still
Check Consistancy of Still on HF - Water System
Develop Preliminary Emission Estimates And Preliminary Ambient Air Concentrations
Measure Vapor-Liquid Equilibrium of Fluorine in Pond Water
Design Ambient Air Sampling System
Check Operation at Ambient Air Sampler
Develop Pond Simulation for Computer
Measure Ambient Air Fluorine Concentrations Downwind of Ponds
Predict Ambient Air Fluorine Concentrations Downwind of Ponds
Verify Emission Estimates by Comparing Predicted and Measured Ambient Air Fluorine Concentrations
Produce Emission Estimates

Figure 2.1 Fluorine emissions from "Wet Process" phosphoric acid plant ponds

3. RESULTS

The goal of this study was to develop and verify a method of predicting fluorine emissions from ponds. Ideally then, one would like to compare calculated emission rates with values measured in the field. Such a comparison would, however, be statistically unsound.

Since water temperature varies over the pond, calculation of emission rates from measured ambient air concentrations requires knowledge of the variation of fluorine vapor pressure with temperature. However, the vapor pressure-temperature relation is also used in the mass transfer equation to make the emission prediction. Thus, if emission rates calculated from measurements of fluorine in the ambient air are used to verify the emission rates calculated from the mass transfer coefficient, vapor pressure becomes part of both the tested and verifying observations. Therefore, statistical comparison of the measured and predicted values would be suspect since the independent variable could not be considered non-stochastic. Section 4.7 discusses the pitfalls of non-stochastic independent variables. In contrast, comparison of fluorine ambient air concentrations calculated from the mass transfer equation and a standard pollutant dispersion model with measured values avoids the statistically unsound comparison of two numbers both dependent on the same observed variable. This latter validation method was used to demonstrate the validity of the emission prediction method and is discussed in detail in Chapter 10.

Based on the statistical conclusions made in Chapter 10 that ambient air fluorine concentrations downwind of ponds , and therefore pond emissions, can be predicted satisfactorily, the emissions estimates for the two ponds studied were calculated as discussed in Chapter 11. The results are presented in Figures 3.1 and 3.2. The portions of the emission estimates shown as solid lines in the figures cover the range of water temperatures and wind speeds actually experienced during the field studies.

Since most fluorine emission regulations are written in terms of pounds of fluorine per unit plant through-put, recasting the emission rate in these units enables the reader to judge the relative importance of pond emissions in comparison to plant emissions. A number of pond emission estimates were made from an optional computer simulation output described in Chapter 9. These estimates were combined with published information on plant capacity to produce emission estimates in the units pounds of fluorine emitted per ton of wet-process acid capacity. Table 3.1 compares the average of these predictions for the two ponds with proposed State of Florida regulations.

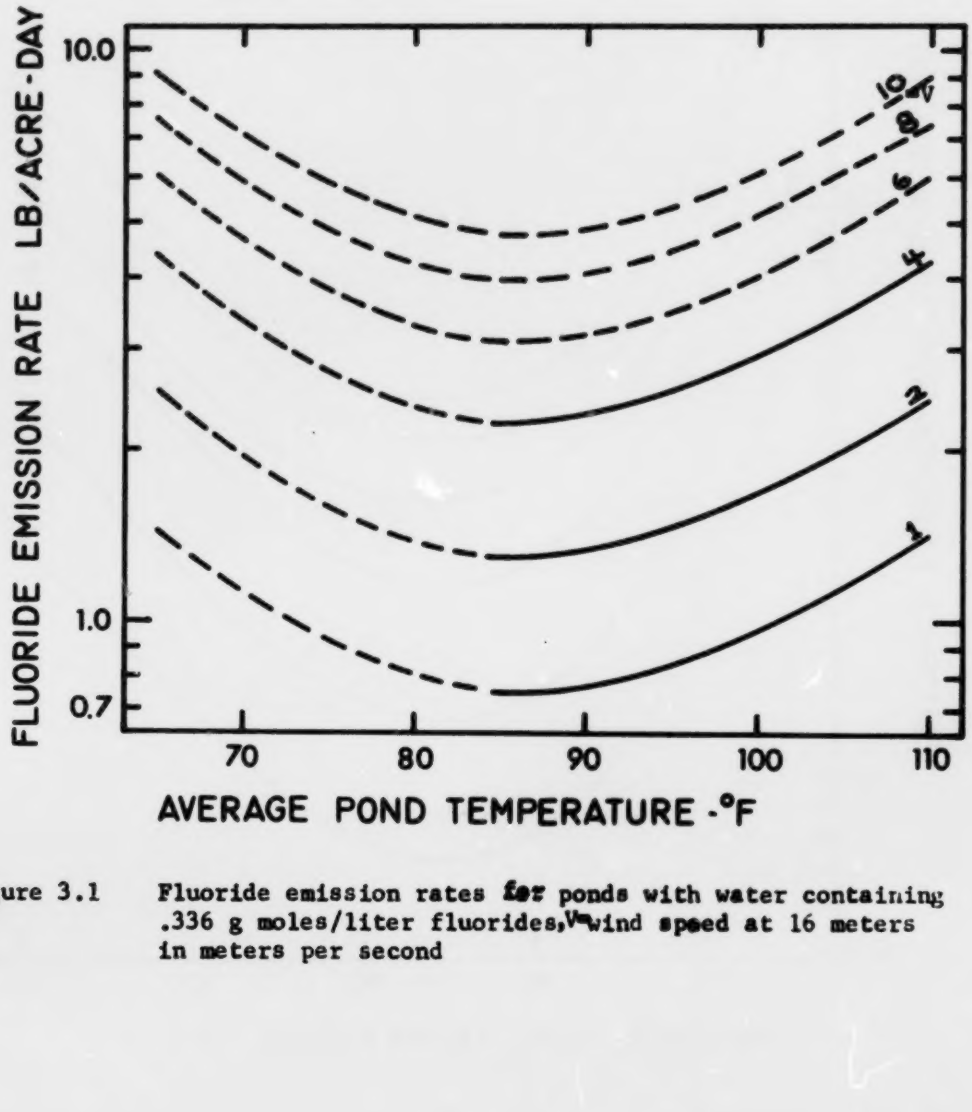


Figure 3.1 Fluoride emission rates for ponds with water containing .336 g moles/liter fluorides, V=wind speed at 16 meters in meters per second

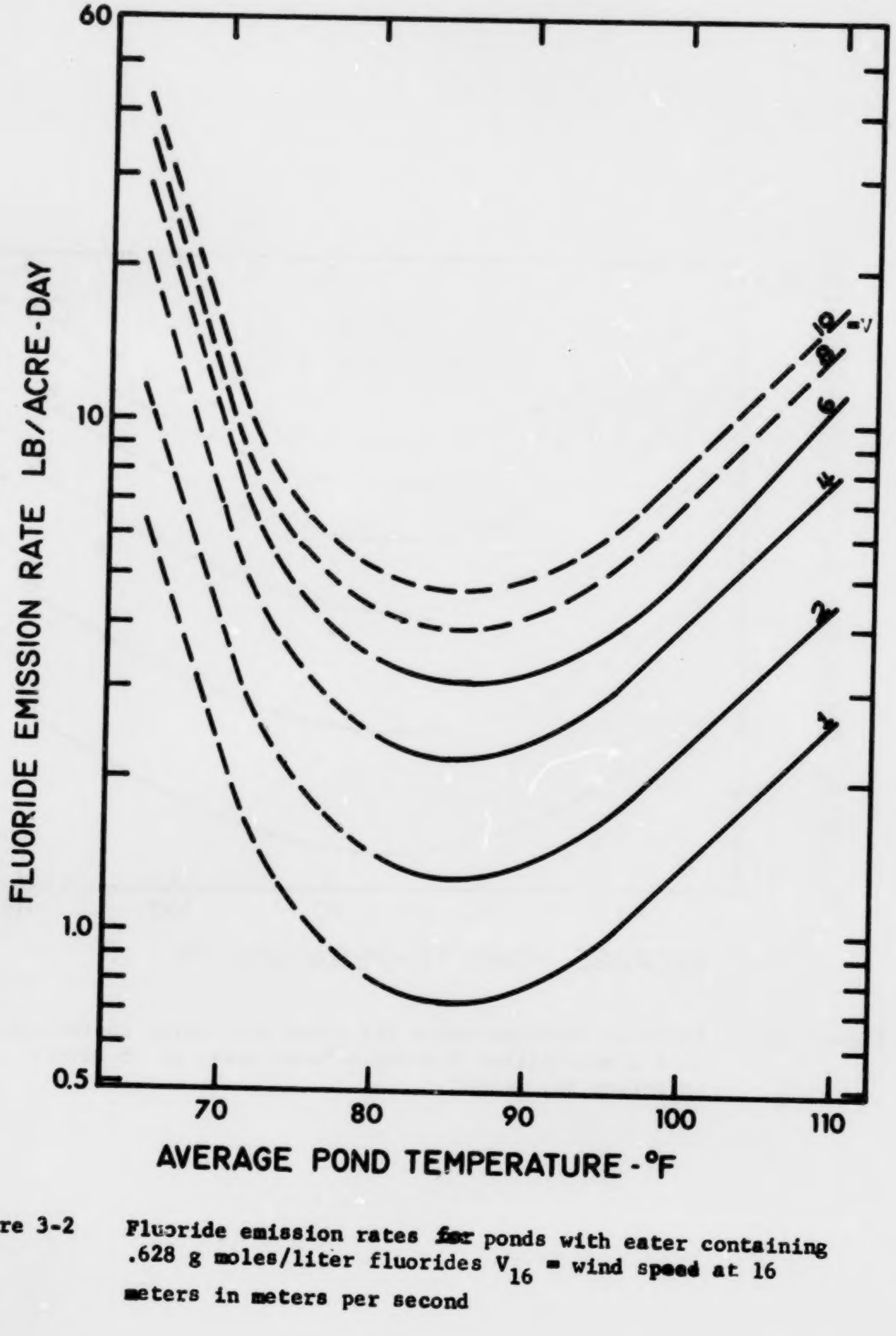


Figure 3-2 Fluoride emission rates for ponds with eater containing .628 g moles/liter fluorides V_{16} = wind speed at 16 meters in meters per second

Table 3.1 Comparison of experimental average fluorine emissions with State of Florida Regulations

	Emission Factor (lb/ton of Wet Acid Capacity Expressed as Tons of P_2O_5)
Pond 10 Predicted Average Emission Rate	.39
Pond 20 Predicted Average Emission Rate	.49
State of Florida [9] Existing Plant Complex - Excluding Ponds	.4
State of Florida [9] New Plant Complex with all Wet Acid Processed to Granular Triple Superphosphate on Site - Excluding Ponds	.17[a]

[a] Emission limit calculation base

1) Wet acid plant -- .02 lb/ton x 1 T P_2O_5

2) GTSP plant -- .11 lb/ton P_2O_5 x 1.39 ton P_2O_5 in GTSP/ton P_2O_5 in wet acid used in manufacture

4. MASS TRANSFER COEFFICIENT

4.1 Introduction

No experimental mass transfer coefficient directly applicable to the evaporation of fluorine from ponds into the atmosphere has been reported, and therefore, methods of estimating a coefficient from other data were reviewed. Well-documented correlations for mass transfer from flat plates into flowing streams which depend only on plate length, velocity and the stream physical properties are available. Most of these correlations were developed from studies of short plates and cannot be applied without verification to a pond many meters long.

Water management engineers have correlated water evaporation rate - a mass transfer coefficient multiplied by a driving force - against wind speed and the driving force for individual ponds. These correlations are based on actual measurements of ponds, evaporation pans, and lakes exposed to the atmosphere. However, since they are site-specific, and in some cases season-specific, the correlations are unsatisfactory for this study.

The empirical form of the mass transfer coefficient correlation documented in the literature was tested against evaporation measurements for ponds, lakes and evaporation pans. The resulting correlation is a general, reliable estimator for the mass transfer coefficient of water from ponds. This correlation was modified into one describing the mass transfer of fluorine from a pond into the atmosphere by correcting for the difference in diffusivity between water and fluorine.

4.2 Model Development

A steady state water (or fluorine) material balance about a stationary, constant pressure, fixed volume element of air at the pond surface (Figure 4.1) yields:

$$y_B M_T + \Delta(wx) k_y (y_{Bi} - y_B) - (y_B + \Delta y_B)(M_T + \Delta M_T) = 0 \qquad (2)$$

where

M_T = molar flow rate of air plus B in the element of air space,

ΔM_T = change in molar flow rate due to evaporation of B into air space,

Δy_B = change in mole fraction of component B over element,

$\Delta(wx)$ = pond surface in contact with the air space element,

w = width of pond perpendicular to air flow,

x = length in direction of air flow,

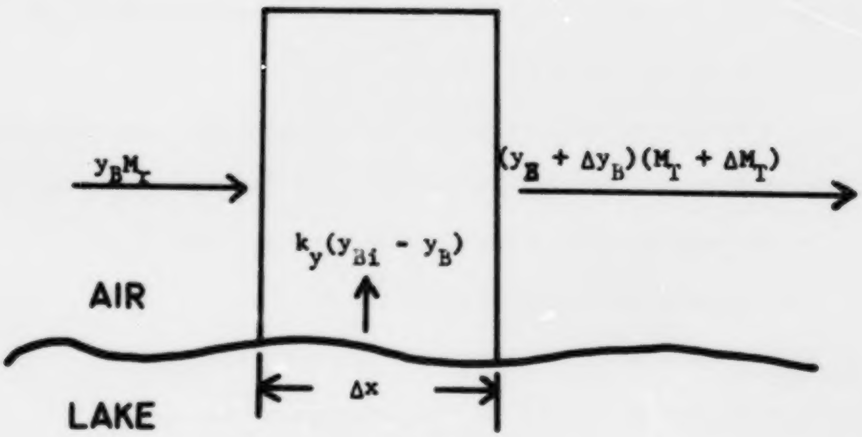
k_y = local, gas-side mass transfer coefficient,

y_B = mole fraction of B in air space element, and

y_{Bi} = mole fraction of B at the air-pond surface interface.

If the assumptions are made

1) the molar flow rate of air plus component B is constant ($\Delta M_T = 0$) (In the case of water evaporation, the change in the molar flow rate (ΔM_T) would only be about 6%, if, initially dry, air was saturated with respect to water at 100°F.),



$y_B M_T$
$(y_B + \Delta y_B)(M_T + \Delta M_T)$
$k_y(y_{Bi} - y_B)$
AIR
LAKE
Δx

Figure 4.1 Mass transfer across lake-air interface

2) y_{Bi} and w are constant across the pond, and

3) the average mass transfer coefficient $\bar{k}_y$ can be substituted for the point coefficient k_y ,

then in the limit as Δx approaches zero, Equation (2) reduces to

$$-dy_B M_T + \bar{k}_y w(y_{Bi} - y_B)dx = 0 \ .$$

Integrating this equation across the pond results in

$$\ln\left(\frac{y_{Bi} - y_{BI}}{y_{Bi} - y_{BF}}\right) = \frac{w\bar{k}_y x}{M_T} \tag{3}$$

where

x = length of pond,

y_{BI} = concentration of B in air at the upwind edge of pond, and

y_{BF} = concentration of B in air at the downwind edge of pond.

Multiplying both sides of Equation (3) by $(y_{BF} - y_{BI})$ and rearranging, yields

$$\frac{M_T(y_{BF} - y_{BI})}{wx} = \bar{k}_y \frac{(y_{BF} - y_{BI})}{\ln\left(\frac{y_{Bi} - y_{BI}}{y_{Bi} - y_{BF}}\right)} = N_B \tag{4}$$

where

N_B = molar evaporation rate of B per unit pond area .

The average mass transfer coefficient from a flat plate into a flowing stream can be predicted [2; 17, p. 487] from the Colburn Analogy when the stream is in turbulent flow.

$$\frac{\bar{k}_y x}{CD_{aB}} = .0365\left(\frac{x\rho u}{\mu}\right)^{4/5}\left(\frac{N}{\rho D_{aB}}\right)^{1/3} \qquad (5)$$

where

C = molar concentration of air,
D_{aB} = diffusivity of B in air,
u = air velocity,
μ = air viscosity,
ρ = air density, and
x = length of plate in the direction of air flow.

Since the physical parameters in Equation (5) do not change significantly over the range of conditions found in the atmosphere, they can be grouped with the constant

$$\bar{k}_y = a''u^{.8}x^{-.2} \ . \qquad (6)$$

Measurement of the gas phase mole fraction of B in equilibrium with the liquid phase (y^*) is much more convenient than measurement of the gas phase interfacial concentration; therefore, the driving force $y^* - y_B$ is usually substituted for $y_{Bi} - y_B$. The applicable mass transfer coefficient becomes the average overall gas side mass transfer coefficient K ; K is equal to $\bar{k}_y$ for a pure liquid such as water. When the content of B in air does not vary across the pond, the linear driving force may be substituted for the log mean driving force. Finally, when the total system pressure is constant, partial pressures may be substituted for mole fractions without affecting the trends in K . With these changes and approximations, Equation (4) reduces to

$$K(P_B^* - P_B) = N_B \tag{7}$$

and Equation (6) becomes

$$K = au^{.8}X^{-.2} \; . \tag{8}$$

Equation (7) was used to produce 24 hour average estimates of K for Lake Hefner and four different evaporation pans; K estimates were correlated against velocity as indicated by Equation (8) and the resulting slopes and intercepts were examined statistically to confirm the dependence of K on velocity to the 0.8 power and pond length to the -0.2 power.

4.3 Data Base for the Water Mass Transfer Coefficient

In 1950 and 1951 the U. S. Government measured water evaporation rates for Lake Hefner [27, 28]. The lake, Figure 4.2, is a water supply reservoir for Oklahoma City with a roughly elliptical shape, about 2.5 by 1.5 miles. About 500 separate daily evaporation rates were measured for the lake during the study. In addition, daily evaporation rates were measured for four class A evaporation pans, one Bureau of Plant Industries (BPI) evaporation pan, one Colorado

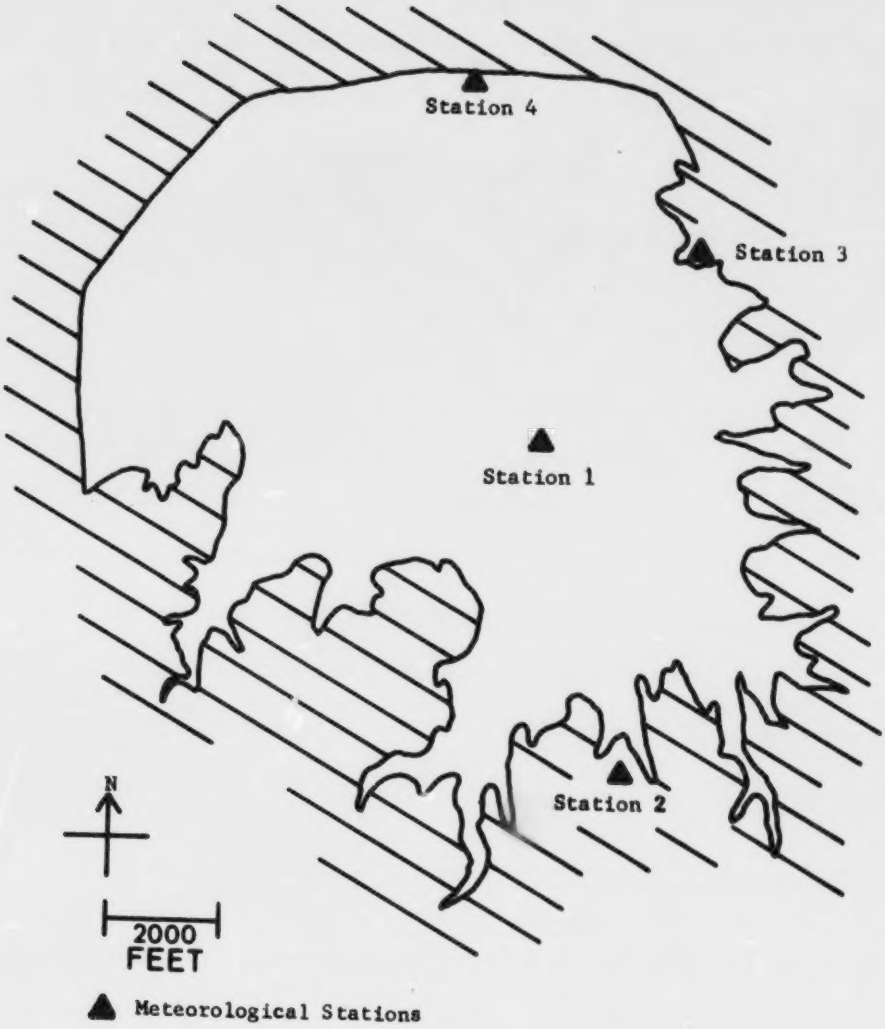

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Figure 4.2 Lake Hefner, Oklahoma

evaporation pan, and one Screened evaporation pan. The physical details of the pans are summarized in Table 4.1.

Evaporation from the lake was not measured directly. It was the calculated residual of all input, output, and accumulation measurements, and therefore, very sensitive to small errors in these measurements. Because of the potentially large effect of errors, only those observations with the smallest estimated errors were used to develop the water mass transfer coefficient. The Lake Hefner study personnel estimated that 142 daily observations fell into this classification; these observations had evaporation rate measurement errors of 0 to about .03 inches/day. The 142 observations were further reduced by eliminating those where the daily average humidity driving force was less than one millimeter of mercury, where the evaporation rate was less than 0.02 inches/day and where the signs of the humidity driving force and the evaporation rate did not agree. One hundred thirteen usable observations remained.

One site on the lake perimeter (Station 2) contained all four types of evaporation pan; experimental observations from this site were used to develop the pan correlations. The pan data for the same 142 days as used in the lake work were evaluated. Again a portion of the observations were discarded. In addition to the reasons cited in the preceding paragraph, observations were discarded if

Table 4.1 Pan structural details

Type	Diameter (Ft.)	Depth (Ft.)	Relation of Water Surface to Ground Surface
Class A	4	0.83	(est)15-18" above ground
Screened (¼ inch mesh screen over top of pan)	2	3	even with ground
Colorado	3 ft. sq.	1.5	even with ground
Bureau of Plant Industries (BPI)	6	2	even with ground

rainfall occurred during the day or if the pan froze. Over 100 usable observations remained[1/].

The partial pressure of water over the pans was calculated at the arithmetic average of the measured maximum and minimum temperatures. The average water temperature at Station 1 was used to calculate the partial pressure of water over the lake.

The 24 hour average, 16 meter wind speed was chosen as the velocity variable since it was the best available approximation to the bulk-average wind speed. Station 2 wind speed observations were used. The humidity measured at Station 2 at the two meter height was chosen as the variable describing the partial pressure of water in the air for two reasons:

1) The fluorine ambient air sampler to be described later was about two meters tall, and
2) preliminary evaluations indicated no appreciable humidity gradient existed.

[1/] The potential errors connected with the discarded observations were large in comparison to the measured values. For example, the wet bulb and dry bulb temperature could be measured with an accuracy of about 0.2°C. On this basis at 80°F, the accuracy of the humidity measurement (the partial pressure of water in the air) is about 0.4 mm Hg. The measurement accuracy of the saturation vapor pressure is about 0.2 mm Hg. Therefore, if the apparent driving force was one millimeter, measurement errors could be over half the measured value.

4.4 Water Mass Transfer Coefficient Development

Linear least squares correlations were developed individually for the logarithmic form of Equation (8)

$$\log_{10}K = \log_{10}(ax^{-.2}) + b \log_{10}u_{16} \tag{9}$$

for Lake Hefner and each of the four evaporation pans. The results and pertinent statistics are shown in Table 4.2. Since values of F larger than about 6.63 can be expected by chance only about one time in a hundred, these correlations are highly significant.

The statistic

$$\frac{(SSE_c - SSE_1 - SSE_2)(n_1' + n_2' - 2q')}{(SSE_1 + SSE_2)k} \sim F_{k,\, n_1' + n_2' - 2q'} \tag{10}$$

where

SSE_c = error sum of squares for the correlation developed from both sets of data,

SSE_1, SSE_2 = error sum of squares for the correlation developed from the individual sets of data

q' = number of regression coefficients in equation (in this case, 2), and

n_1', n_2' = number of data points in data set

was used to determine whether the difference between individual correlations was statistically significant. The BPI Pan and the

Table 4.2 Summary of correlations[a] developed for Lake Hefner and for evaporation pans to describe the mass transfer coefficient

Data Base	$\log_{10}(ax^{-.2})$ (Standard Error)	b (Standard Error)	Number of Observations	F	R^2
Class A Pan	-.1601 (.04390)	.5839 (.06093)	103	91.808	.4762
BPI Pan	-.2994 (.04427)	.6985 (.06196)	100	127.927	.5662
Colorado Pan	-.3761 (.04041)	.7938 (.05686)	105	194.905	.6542
Screened Pan	-.4786 (.05391)	.8323 (.07528)	109	122.211	.5451
Lake Hefner	-.3640 (.04326)	.8162 (.06186)	114	174.119	.6086
Colorado + BPI + Lake	-.3486 (.02477)	.7727 (.03497)	319	488.254	.6063

[a] $\log_{10}K = \log_{10}(ax^{-.2}) + b \log_{10} u_{16}$

K = g moles/hr m^2 mm Hg

u_{16} = 16 meter velocity in meters/second

Colorado Pan correlations were each compared with the Lake Hefner correlation; the differences were not found to be statistically significant at the 95% confidence level. The three sets of data were merged, and a new correlation was developed. This correlation is also shown in Table 4.2. The merged data correlation was tested against the remaining single pan correlations. Both the Screened Pan and the Class A Pan correlations were significantly different from the merged data correlation; however, the slope of the Screened Pan correlation was not significantly different from 0.8 as demonstrated by the two-tailed Student's t test.

Finally, the two-tailed Student's t test was used to show that the slope of the merged data correlation was not significantly different at the 95% confidence level from the anticipated value of 0.8.

Figure 4.3, a plot of wind speed against mass transfer coefficient, compares the Lake, BPI, and Colorado data against the best fit, 0.8 slope line. This latter correlation is the recommended estimator of the overall, gas-side mass transfer coefficient for the transfer of water from a pond or lake to the atmosphere. In exponential form it is

$$K = .429\, u_{16}^{.8} \tag{11}$$

where the units are

$$K = \frac{\text{gram moles } H_2O}{M^2 \text{ hr mm Hg}} \text{ , and}$$

u_{16} = wind speed at 16 meters in meters/second.

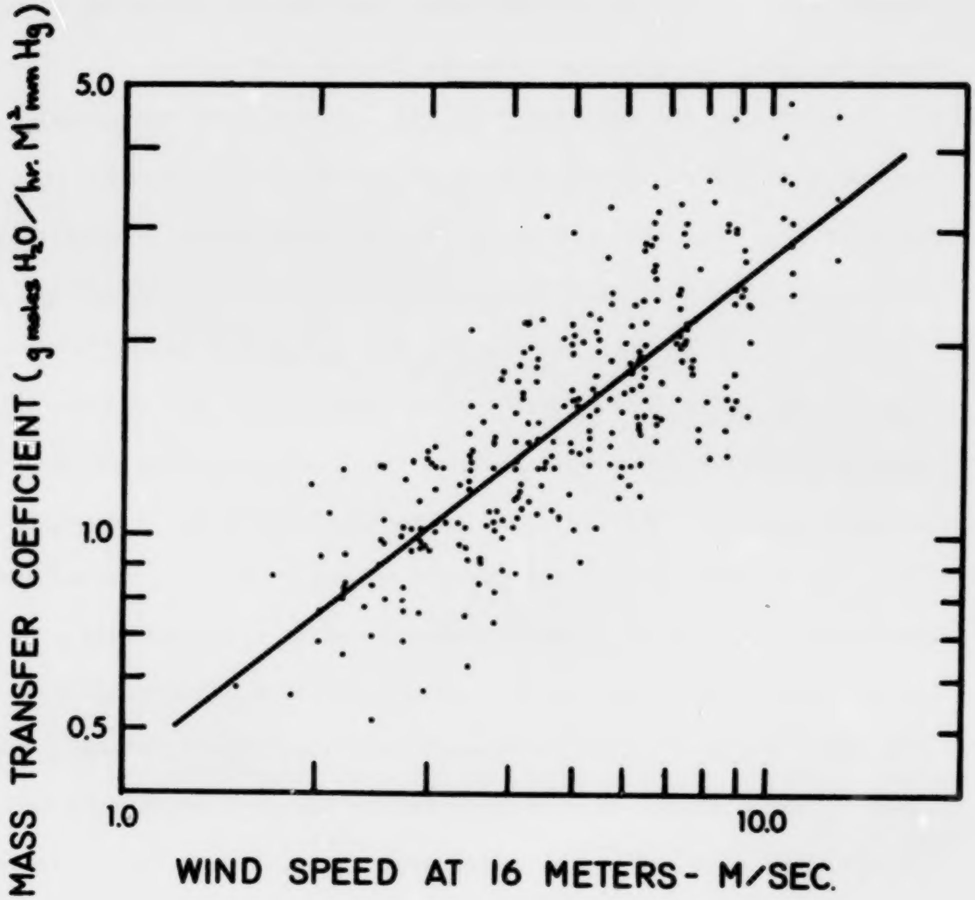

Figure 4.3 BPI Pan, Colorado Pan and Lake Hefner, Data compared with recommended mass transfer coefficient

$k = .429\ u_1^{.8}$

4.5 Discussion of Results

The statistical analysis has demonstrated that the evaporation rate of water from the lake and the BPI, Colorado and Screened Pan is dependent on $u_{16}^{.8}$. It further shows that evaporation rates of water from the lake, the BPI, and Colorado Pan are the same.

The BPI and the Colorado Pans are set even with the ground surface and open to the atmosphere as a pond is, so the fact that mass transfer from them is the same as from the lake is not particularly surprising. The Screened Pan, which is also set into the ground, is covered by a screen that reduces the air turbulence above the water at a given wind speed. As a result the velocity multiplier, $(ax^{-.2})$, would be expected to be smaller than the lake multiplier but the velocity exponent, (b) would not be expected to change. Experimentally these trends were noted. The Class A Pan sits about 15 inches above the ground which makes it more like a circular cylinder than a flat plate. Wake separation can be expected to occur. There has been no work done specifically to define mass transfer from a cylinder head; however, measurements of mass transfer to fluids flowing past the curved surface of cylinders, rectangular bars, streamlined cylinders, and spheres where wake separation occurs demonstrates that in these cases the mass transfer coefficient depends on velocity to the .5 to .65 power. On this basis the observed $u^{.58}$ dependency of the Class A Pan's mass transfer coefficient is reasonable.

Equation (7) postulates that the mass transfer coefficient depends upon the distance that the wind blows across the pond or pan. The correlation was based on laboratory studies of relatively short flat plates. The air velocity profile was developed after the air moved past the leading edge of the plate. In contrast air passing from land to water already has a developed velocity profile. (However, differences in skin friction may cause minor changes in the profile.) The effect of pond length on the mass transfer coefficient has been statistically tested in Section 4.4 and found not significant. However, to test further for the length dependency, the ratio of the K's predicted by Equation (5) and Equation (11) was calculated

$$r = \frac{.036\ CD_{aw}\left(\frac{\rho}{\mu}\right)^{.80}\left(\frac{\mu}{\rho D_{aw}}\right)^{.33}\frac{1}{P}X^{-.2}u_{16}^{.8}}{.429\ U_{16}^{.8}} \tag{12}$$

$$r = \frac{.0523\ x^{-.2}}{.429}(\text{Meters})^{.2}\ .$$

If the assumption is made that Equation (11) and (5) are the same equation, then r is equal to 1.0 and x is equal to 12,000 meters. On the basis of the above calculation, the pans and lake have an average mass transfer coefficient equal to the average for a flat plate about 7.6 miles long. In terms of magnitude, the value of the average coefficient for the lake and pans is much smaller than for the short flat plates used in the wind tunnel work.

If the equivalent length (x) of the pans is assumed to be 12,000 m and the lake 12,000 m plus two miles, the ratio of the empirical values of $ax^{-.2}$ in Equation (11) should be 1.045. Table 4.2 shows that the ratio of the average value of $ax^{-.2}$ of the BPI and Colorado pans to the lake value of $ax^{-.2}$ is 1.070. On the basis of this evidence, perhaps a length effect does exist, but as demonstrated in Section 4.4, it is statistically insignificant and as demonstrated in this paragraph numerically unimportant in the estimation of mass transfer from moderately sized bodies of water.

In the development of the mass transfer model, three assumptions concerning the driving force were made:

1) The water content of the air did not vary across Lake Hefner.
2) The water content of the air did not vary vertically.
3) The lake water temperature, and hence the equilibrium water partial pressure, is constant across the lake.

None of these assumptions is strictly correct; however, the errors introduced in using them are of the same magnitude as the accuracy of the measurements and their effects are approximately random. Therefore, their use in this study increases the experimental variance but does not introduce a systematic bias. For a detailed analysis of the assumptions, see Section 15.1.

4.6 Comparison of Correlation Against Other Available Data

Figure 4.4 compares the mass transfer correlation developed in this study against some of the other usable evaporation data [10, 18]. In developing this graph most of the wind speed data had to be adjusted to the 16 meter speed using the wind velocity profile estimates developed for this report and assuming adiabatic conditions. Within

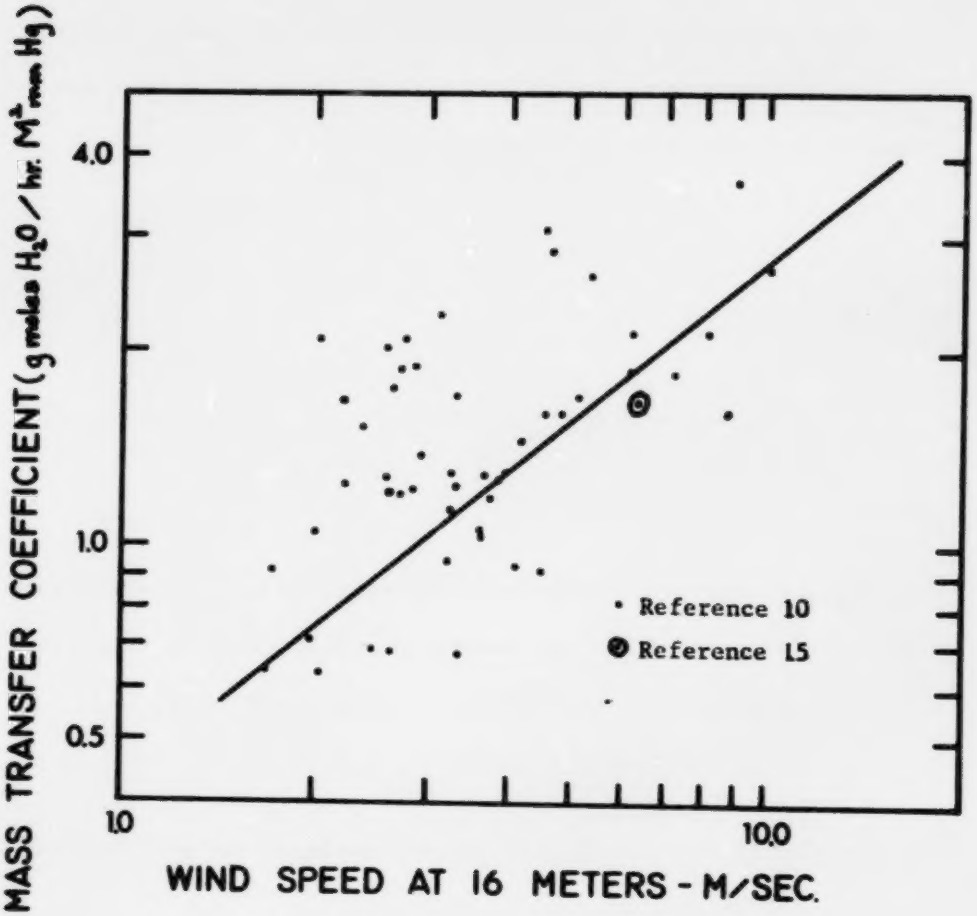

Figure 4.4 Comparison of correlation against other available data

the limits of the data and the experimental detail reported, the correlation describes the data satisfactorily.

4.7 Previous Correlations

Most theoretical equations in the literature which describe evaporation from lakes and ponds begin by integrating the mass transfer and the momentum transfer equations

$$\int_0^{2_j} \frac{N_B}{A}\, dz = -D_{Ba}(C) \int_{y_{Bi}}^{y_{B1}} dy \tag{19}$$

$$\int_0^{Z_1} \frac{\tau_{gc}}{\rho}\, dz = \left(\frac{\mu}{\rho}\right) \int_0^{u_1} du \tag{20}$$

where

N_B = constant = molar mass transfer of B per unit area,

τ = constant = sheer stress in air at air water surface,

y = mole fraction of species being transferred, and

gc = gravitational constant,

to the edge of the atmospheric laminar sublayer and eliminating z ,

$$N_B = \frac{D_{Ba}C}{\mu/\rho} \frac{gc\ \tau/\rho}{u_1}(y_{Bi} - y_{BI}) \ . \tag{21}$$

Assuming the velocity profile is described by

$$\frac{u_1}{U^*} = \frac{\ln(\frac{Z_1}{Z_0})}{K_0} \tag{22}$$

where

$u^* = \sqrt{\tau_{gc}/\rho}$,

Z_0 = surface roughness parameter, and

K_0 = von Karmans constant.

Equation (21) reduces to

$$N_B = \frac{D_{Ba}(C)}{\mu/\rho} K_0^2 \frac{u_1(y_{Bi} - y_{BI})}{(\ln Z_1/Z_0)^2} . \tag{23}$$

Equations of this form have several inherent flaws. The primary ones are the implicit assumption that the turbulent velocity profile (Equation (22)) extends to the pond surface and the use of a number of physical constants that hold only for laminar conditions with the turbulent flow velocity profile. The upper limit is also a problem since Equation (22) holds to a maximum u/U^* value of about 20 or a y^+ of about 400; as discussed later, this limit is probably exceeded at a height of less than 2 meters for Lake Hefner. Finally Z_0 is an empirical term which must be evaluated for each site.

Some workers have attempted to account for the laminar sublayer with a two layer model [27, p. 59]:

$$N_B = \frac{D_{Ba}C}{\mu} \quad \frac{\rho K_0 U^*(y_{Bi} - y_{BI})}{\ln(\frac{S + Z_0}{z_1 + Z_0} + \frac{K_0 z_1 U^*}{D_{wa}})} , \tag{24}$$

S = thickness of laminar plus transition layers in the atmosphere over a pond, and still others have attempted to account for the effects of thermal gradients on mass transfer [27, p. 60]

$$N_B = \frac{D_{BA}C}{\mu} \frac{K_0^2 \, u(1-D)^2 (y_{Bi} - y_{BI})}{((Z_1/Z_0)^{1-D} - 1)^2} , \qquad (25)$$

D = empirical constant,

> 1 for super adiabatic conditions,

$= 1$ for adiabatic conditions, and

< 1 for stable conditions .

Equations (23), (24), and (25) were tested in the Lake Hefner study with relatively unsatisfactory results [27, p. 65]; Equations (23) and (25) predicted evaporation rates twice the observed values on the average. Equation (24) predicted evaporation rates on the average 12% greater than observed.

Strictly empirical equations have been used to develop statistically significant correlations [27, pgs. 65, 133, 137]; these equations usually are of the form

$$N = (p^* - p)(a' + b'u_x) .$$

However, the correlation coefficients have varied from evaporation source to evaporation source as shown in Table 4.3. This table summarizes the pan and lake correlations developed in the Lake Hefner Study[2/].

[2/] All velocity dependent coefficients in the table were corrected to the 16 meter velocity with the assumption that velocity varied as the 0.23 power of height (average for Lake Hefner).

Table 4.3 Summary of evaporation rate equations developed by Lake Hefner Study Group

Surface	Days of Record	Dependent Variable	Independent Variable	Regression Coefficients		Standard Error (g/moles m^2 hr)	R^2
				a'	b'		
Class A Pan	266	N^a	u,Δp	.965	.261	.112	.85
BPI Pan	288	N	u,Δp	.585	.261	.092	.83
Colorado Pan	285	N	u,Δp	.490	.286	.115	.79
Screened Pan	292	N	u,Δp	.240	.286	.113	.74
Lake	141	N	u,Δp	.189	.219	.090	.89
Lake (this study)	114	K^b	u	.266	.275	(gmoles/m^2 hr mm Hg) .49	.615

[a] $N = \Delta p(a' + b'u_{16})$

[b] $K = a' + b'u_{16}$

For comparison, the last row on this table is the linear correlation of mass transfer coefficient against velocity - $K = a' + b'u_{16}$ - using the same lake data base as the log correlations developed earlier. The correlation statistics for this linear correlation of the mass transfer coefficient are about the same as the log correlation developed in Section 4.4 but significantly poorer than the evaporation rate correlation developed during the Lake Hefner studies. The following paragraphs discuss the reasons for the differences and show that the excellent correlation of the evaporation rates are due to the use of statistically faulty correlating equations.

The mass transfer coefficient of Table 4.3 is correlated as

$$K = a' + bu' \ . \qquad (26)$$

The product of the mass transfer coefficient and the appropriate driving force provides estimates of the evaporation rate

$$N = K(\Delta p) = (a' + b'u)\Delta p \ . \qquad (27)$$

In Equation (27) the driving force is part of the independent - $K\Delta p$ - and both dependent variables - Δp and Δpu . Because the driving force appears in every term, Equation (27) has two problems statistically:

1) It contains a high degree of multicollinearity in the independent variables $\Delta p = f(\Delta pu)$,
2) The form of the equation puts considerable strain on the assumption that the independent variables

are non-stochastic; that is, no correlation exists between the independent variables and the error [16, p. 297-306].

A high degree of multicollinearity in the independent variables yields estimates of the least squares regression coefficients that are imprecise [16, p. 380-391]. One measure of the degree of multicollinearity is to compare R^2 calculated with and without one of the independent variables. If there is a high degree of multicollinearity, the R^2 calculated for the model containing both independent variables will be only slightly larger than one containing only one of the independent variables. In Table 27 of reference [27, p. 137], the results of using the model described by Equation 27 to correlate a set of observed Lake Hefner evaporation rates were reported; R^2 was .916. Removal of the Δp term from the correlating equation reduced R^2 to .914 , a .002 change.

To test the concept of non-stochastic independent variables, Equations (26) and (27) are rewritten in terms of the true value plus an error term

$$N - e_1 = (\Delta p + e_2)(a' + b'(u + e_3)) \tag{26a}$$

and

$$\frac{N - e_1}{\Delta p + e_2} = K + e_4 = a' + b'(u + e_3) \ . \tag{27a}$$

Expanding the equations and eliminating error product terms - $(e_i)(e_j)$ - results in

$$N = \Delta p(a' + b'u) + (e_2(a' + b'u) + e_3\Delta pb' + e_1) \qquad (26b)$$

$$\frac{N}{\Delta p} = a' + b'u + \frac{e_1}{\Delta p} + b'e_3 \ . \qquad (27b)$$

The magnitude of the error terms at the variable mean value are, in the British units of the Lake Hefner study,

$$e_2(a' + b'u) = .0228 \text{ in/D} \ ,$$

$$e_3\Delta pb' = .013 \text{ in/D} \ ,$$

$$e_1 = .030 \text{ in/D} \ ,$$

$$\frac{e_1}{\Delta p} = .097 \text{ in/D mm Hg} \ , \text{ and}$$

$$b'e_3 = .042 \text{ in/D mm Hg} \ .$$

When the data is analyzed in the form of Equation (27), fifty five percent of the "average error" is correlated with the independent variables

$$\frac{e_2(a' + b'u) + e_3\Delta pb'}{e_1 + e_2(a'+b'u) + e_3\Delta pb'} = .55 \ .$$

In contrast only 30% of the "average error" is correlated with the independent variables

$$\frac{b'e_3}{\frac{e_1}{\Delta p} + b'e_3} = .30$$

when the data is analyzed in the form of Equation (26). Although neither model strictly satisfies the non-stoichiometric requirement, Equation (27) puts more strain on it. Therefore, the least squares estimates of a' and b' made using Equation (27) may be inconsistent.

This exercise also yields a clue as to why so much of the experimental variance is explained by the Equation (27) model; most of the error was correlated with the independent variables.

4.8 Fluorine Mass Transfer Coefficient Development

Equation (5) shows that the gas side mass transfer coefficient for small concentrations of the species being transferred varies from species to species, only as diffusivity of the species in air varies.

$$\frac{\bar{k}_{aw}}{\bar{k}_{af}} = \left(\frac{D_{aw}}{D_{af}}\right)^{2/3} \tag{28}$$

where subscript

f = fluorine,

w = water, and

a = air.

Because the contents of a lake or pan are essentially pure water, the assumption was made that the average overall gas side coefficient was approximately equal to the average gas side coefficient

$$\bar{k}_y = K . \tag{29}$$

For fluorine in a pond this assumption must be examined. The gas-side overall mass transfer coefficient can be written in terms of the two individual coefficients[3]:

$$\frac{1}{K} = \frac{1}{\bar{k}_y} + \frac{M}{\bar{k}_1} \tag{30}$$

where

K = overall mass transfer coefficient,

$\bar{k}_y$ = mass transfer coefficient from the liquid-gas interface to the bulk of the gas stream,

$\bar{k}_1$ = mass transfer coefficient from the bulk of the liquid to the liquid-gas interface, and

M = slope of the vapor-liquid equilibrium line.

On the assumption that the volatile species is H_2SiF_6, the slope (M) can be estimated; according to measurements made by Tartera [25], the slope for H_2SiF_6 in water is 1.15×10^{-3} at 77°F. For the liquid-side resistance term - M/k_1 - to contribute even 10% of the total value of K for fluorine, k_1 would have to be 100 times less than k_y, an unrealistically small value. This argument that k_1 does not significantly affect K, bolstered with the experimental observation that the vertical fluorine concentration in the pond is constant, makes the assumption tenable that

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[3] The following assumptions are necessary to write Equation (30): 1) $\bar{k}_y$ is independent of $\bar{k}_1$; 2) the processes are in series; and 3) there is no interfacial resistance

$$\bar{K}_{yf} = K_f \ . \qquad (31)$$

Therefore, the fluorine mass transfer coefficient is simply the water coefficient corrected for gas phase diffusivity differences.

No study, including this one, has documented the fluorine species evaporating from the pond. In order to estimate fluorine diffusivity, the assumption was made that

$$H_2SiF_{6(L)} \rightarrow 2HF_{(g)} + SiF_{4(g)} \ .$$

Since all work and results are in terms of atomic fluorine, the effective fluorine diffusivity based on the above reaction should be

$$D_{af} = \frac{2D_{aHF} + 4D_{aS_iF_4}}{3} = \frac{2(.234) + 4(.106)}{3} \ cm^2/sec$$

$$= .297 \ cm^2 sec \qquad (32)$$

at 77°F. At the same temperature (298°K) the diffusivity of water in air is .248 cm^2/sec. Therefore, the overall mass transfer coefficient for fluorine in air is

$$K_f = K(\frac{D_{af}}{D_{aw}})^{2/3} = 1.128(.429 \ u_{16}^{.8})$$

$$K_f = .484 \ u_{16}^{.8} \qquad (33)$$

where the units of K_f are g moles fluorine/M^2 hr mm Hg and u_{16} is the 16 meter wind speed in meters/second. Other assumptions, such as HF is the only volatile species, would not yield grossly different diffusivity estimates.

5. WIND SPEED PROFILE

5.1 Introduction

During the field measurements of ambient air fluorine concentrations, wind speed was measured at 3.05 meters above the ground. Since wind speed varies with height above the earth for at least the first 125 meters [6] estimates of the wind velocity were needed at

1.67 meters - sampling height
10 meters - stability class prediction
16 meters - mass transfer coefficient prediction.

In the following paragraphs the necessary wind speed predictor is developed.

5.2 Model Development

Two empirical equations are generally used to describe the velocity profile

$$\frac{u_i}{u_j} = m \log \frac{z_i}{z_j} \tag{34}$$

and

$$\frac{u_i}{u_j} = (\frac{z_i}{z_j})^n \tag{35}$$

where

$u_{i,j}$ = velocity at height z_i ,

$z_{i,j}$ = height above earth, and

m,n = empirical constants.

The log-velocity profile results from Nikuradse's empirical velocity profile work in the turbulent layer. Pasquill [23] suggests that

$$u/u^* = 2.5 \log_e \frac{z}{Z_0} \tag{36}$$

$$u^* = \sqrt{\frac{\tau_g g_c}{\rho}} = u_B \sqrt{f/2}$$

where

f = friction factor

describes the atmospheric velocity profile over a rough surface. Knudson and Katz [17, p. 169] suggest that Equation (35) fits the experimental data for flat plates better than the log form at reduced heights (y^+) in the range

$$400 < y^+ < \text{edge of boundary layer}$$

where

$$y^+ = \frac{zu^*\rho}{\mu} . \tag{38}$$

The value of the exponent n in Equation (35) seems to vary from about .2 for smooth plates or plates having wavy surfaces [17, p. 274] through about 0.22 for plates having "a few shallow indentations" up to about .32 for surfaces with well defined properties [17, p. 281].

Theoretical studies by Deissler as reported by Knudson and Katz [17, p. 165] indicate that the power term may be about 50% greater when the gas (air) is being strongly cooled by the plate (inversion condition in the atmosphere) than when the plate and air are the same temperature. Strong heating (super adiabatic condition in the atmosphere) by the plate reduces the power term by about 50%.

Y^+ values for a number of the reported Lake Hefner velocity profiles were calculated. Estimates of τ_g were obtained by extrapolating the velocity profiles from 2 meters to ground level. Even with 16 meter wind speeds as low as 1.4 m/sec , Y^+ values in excess of 400 were calculated at the 2 meter level. Since all the Lake Hefner velocity measurements were made at 2 meters or above and since, for the most part, this study is concerned with wind speed at heights greater than 2 meters, the Lake Hefner velocity profile data was used to develop a correlation for the exponent, n , in Equation (35).

From the above discussion n should vary with the temperature gradient through the atmosphere . However, examination of the data indicated that n also varied with velocity. Neither Equation (34) or (35) predicts this dependency[4/].

[4/] An equation $u/u_B \sqrt{f/2} = 5.5 + 2.5 \ln(\frac{z\rho}{\mu} u_B \sqrt{f/2})$ describing the velocity profile over smooth flat plates between $10 < Y^+ < 400$ does predict the dependency. However, it was not used to correlate the data because of the difficulty of estimating the bulk average wind speed, u_B , (or τ) and because previous Y^+ estimates indicated that the Lake Hefner data was outside the correlation range.

5.3 Data Base

Two hundred eighty three three-hour-average velocity profiles measured in the Lake Hefner Study [28] were plotted against height (2, 4, 8, and 16 meters) on log-log graph paper. A straight line was fitted through the points, and the velocity profile exponent, "n" , was measured. The data base was all usable data for about 40 days chosen at random from the 142 days used to develop the mass transfer coefficients. Station 2 observations only were used. Temperature lapse (L), defined as the temperature at 16 meters minus temperature at 2 meters, and the wind speed at 16 meters (u_{16}) were chosen as the independent variables. Wind speed measurements were accurate to about .25 m/sec. The maximum expected error in "n" is about 0.03. Temperature was measured with a reported accuracy of 0.1°C. The experimental observations had the following ranges:

$$-1.4 \leq L \leq 4.0^\circ C$$

$$10 \geq L/L_A \geq -30$$

$$1.1 \leq u_{16} \leq 10.5 \text{ m/sec}$$

$$.1 \leq n \leq .60$$

where $L_A = -.134^\circ C$ = adiabatic lapse. The adiabatic lapse is defined as the temperature drop that an element of air would experience as it moved from a lower to a higher altitude (2 to 16 meters in this study) expanding adiabatically.

5.4 Wind Speed Profile Exponent

Table 5.1 lists the various models tried. With 283 observations, F at the 95% confidence level is less than 3.9 for all correlations; therefore, the correlations are all significant. As models (A) and (B) show, temperature lapse explains more of the observed variance in n than wind speed. Equation (E), the linear combination of lapse and wind speed explains significantly more variance than the independent variables do singularly. No other combination significantly improved the estimated value of R^2 . Therefore, wind speed variation with height is described by

$$u_1 = u_2\left(\frac{z_1}{z_2}\right)^n \tag{39}$$

where

$$n = .2909 + .06154\ (L) - .01164\ (u_{16})\ .$$

Equation I, Table 5.1, shows the relation of temperature lapse and wind speed. The two variables are not highly correlated; however, the correlation is statistically significant. The lapse tends to be large and positive at low wind speeds and large and negative at high wind speed.

5.5 Discussion of Velocity Profile Exponent

The velocity profile exponent - n - correlation is empirical and developed for one site so the obvious question arises - are the numbers

Table 5.1 Correlation of "n" -- the velocity profile exponent

Model (Standard Error of Regression Coefficient)	F	R^2
A. $n = .3313 - .01805\ U_{16}$ $(.01303)(.002054)$	77.20	.2155
B. $n = .2236 + .07315\ L$ $(.005062)(.005700)$	164.68	.3695
C. $n = .2178 + .1680\ \frac{L}{U_{16}}$ $(.005575)(.01699)$	97.75	.2581
D. $n = .2196 + .2342\ \frac{L}{(U_{16})^2}$ $(.006050)(.03532)$	43.97	.1353
E. $n = .2909 + .06154\ (L) - .01164\ (U_{16})$ $(.01154)\ (.005635)\ (.001820)$	114.47	.4498
F. $n = .2911 + .05945\ (L) - .01160\ (U_{16}) + .00005237\ (U_{16}L)$ $(.01158)(.01132)\ (.001831)\ (.002464)$	76.07	.4499
G. $n = .2954 + .07927\ (L) - .008859\ (L)^2 - .01139\ (U_{16})$ $(.01148)(.008197)\ (.003010)\ (.001798)$	81.29	.4664
H. $n = .3408 + .05884\ (L) - .03109\ (U_{16}) + .001530\ (U_{16})^2$ $(.02298)(.005684)\ (.007939)\ (.0006079)$	79.88	.4621
I. $L = .6559 - .1041\ U_{16}$ $(.1157)\ (.01823)$	32.58	.1039

L = temperature 16 m - temperature at 2 m (°C)

U_{16} = 16 meter wind speed (m/sec)

and trends predicted believable and can the correlation be used elsewhere? From the Model Development discussion, the following trends would be expected.

1) Since a positive lapse rate is equivalent to the ground cooling the air, n should be greater if the temperature lapse $(T_{16} - T_2)$ were positive and less if lapse were negative. This trend is observed in the correlation.
2) The lapse rate should be more important than wind speed. In the correlation lapse explains more of n's observed variation than wind speed.
3) The velocity profile exponent, n , would be expected to vary between about .20 and .30 when temperature lapse is zero. The correlation predicts n of .28 at the lower limit of observed wind speeds (1.1 m/sec) and .17 at the upper limit (10.5 m/sec).

The correlation of n does follow the trends that are predicted in the model development.

De Marrais (6) has summarized the available measurements of n for a number of different sites into four stability classes which depend on temperature lapse rate.

Inversion $\frac{L}{L_A} < 0$

Stable $.18 \le (L/L_A) \le .8$

Neutral $.90 \le L/L_A \le 1.$

Superadiabatic $L/L_A \geq 1.1$.

The n data reported by De Marrais[5] was compared to range values calculated from Equation (39) using De Marrais' temperature ranges and this study's experimental velocity range. Figure 5.1 illustrates the comparison. Each different symbol in this figure represents data taken at a different site. Although the ranges predicted by the correlation and De Marrais' values do not mesh exactly, the agreement is good enough to give confidence in applying the correlations to other sites.

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[5] The observations of n differentiated as day and night in De Marrais' table were assigned to the superadiabatic and inversions ranges, respectively.

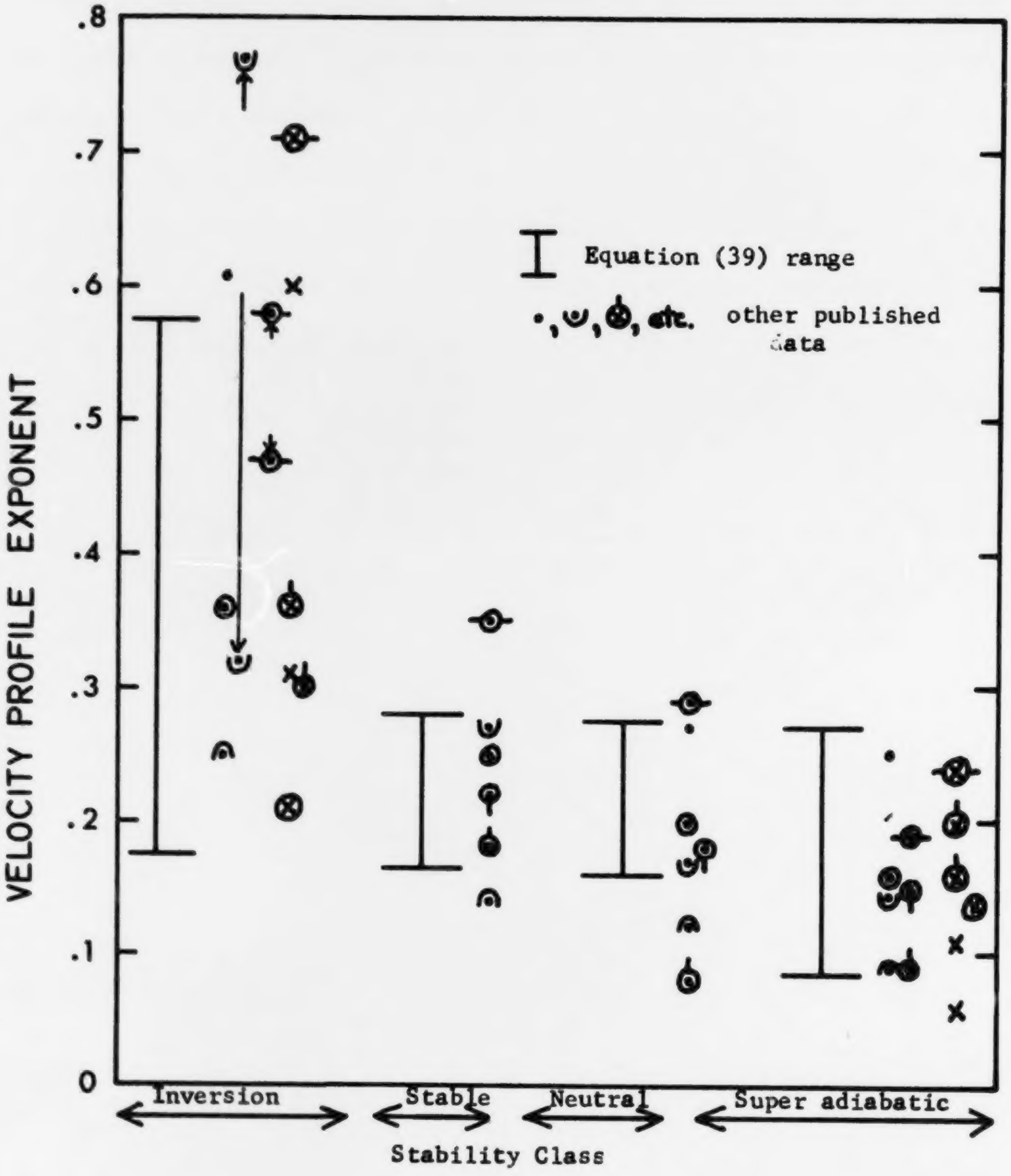

Figure 5.1 Comparison of velocity profile exponent predicted by Equation (39) with other published data

6. FLUORINE ANALYTICAL METHODS

All fluorine samples were analyzed in the liquid phase. The samples were diluted to the concentration range of 10^{-4} to 10^{-5} g moles fluorine per liter before analysis with a fluoride ion activity electrode. The total ionic strength and Ph of the solutions analyzed were controlled by adding 10 volume percent of Orion Research Inc. Total Ionic Strength Adjustment Buffer.

Christ [4], in reporting the results of an interlaboratory comparison on analysis of fluorine samples noted that the two laboratories using the fluoride ion activity electrode agreed well with each other. One laboratory distilled fluorine from perchloric acid to free the sample from interferences; the second used a buffer to complex potential interferences and analyzed the solution directly. Examination of Table III of Christ's memo shows that the analyses made using the fluoride ion activity electrode also agree with both SPADNS (reaction of fluorine with $Zn\ OCl_2$ dye) and the thorium-nitrate-titration-after-perchloric-acid-distillation methods for determining fluorine.

Appendix 15.2 details the analytical procedure used in this study. Five samples of pond waters and condensed fluorine vapor covering the concentration range of interest were analyzed a total of twelve times; the analytical standard deviation expressed as a percentage of the mean value of the individual samples was 0.516%.

7. VAPOR-LIQUID EQUILIBRIUM FOR THE POND WATER-FLUORINE SYSTEM

7.1 Literature Review

Tatera's study [25] of fluorine vapor pressure over pond water is the only study reported in the open literature. He worked with samples of pond water that had been diluted in the ratio of about 1.5 volumes of distilled water to 1 volume of pond water [25][6]. Fluorine vapor pressure of mixtures of diluted pond water and either hydrofluoric acid (HF) or hydrofluosilicic acid (H_2SiF_6) were measured. Unfortunately dilution destroys any equilibrium that may have existed in the liquid phase and affects the fluorine vapor pressure as discussed in Section 7.2.

Two other sources cite single values for fluorine vapor pressure over pond water with no description of the measurement technique. These values are tabled below:

Fluorine Vapor Pressure (x 10^{-6} mm Hg)	Temp. °F	Pond Water Fluorine Concentration g moles/L	Reference
1300	64.4	.632	7
13.8	77	.526	1

The value reported in reference [7] is approximately the same as the value measured in this study; the value of reference[1] is a factor of 30 less than in the present study.

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[6] Tatera, B. 11/10/72. Private communication to W. King.

7.2 Experimental Results and Discussion

Fluorine vapor pressure curves were developed for the water in Ponds 10 and 20. These ponds were the subject of the field studies which measured ambient air fluorine concentrations downwind of the ponds. Two samples of Pond 10 water taken about six months apart and containing different fluorine concentrations were studied; one sample of Pond 20 water was studied. Vapor pressure was measured in the Othmar Still described in Section 7.3. Vapor and liquid samples were analyzed as described in Chapter 6. The measured fluorine concentrations in the condensed vapor phase were converted into vapor pressures as shown in Appendix 15.8. The vapor pressure measurements in Tables 7.1, 7.2 and 7.3 are shown graphically in Figure 7.1

The vapor pressure lines in Figure 7.1 were developed by plotting smooth curves through the arithmetic average vapor pressure of each pond water at each temperature. More sophisticated curve fitting procedures were not attempted because classical equilibrium theory does not directly yield the form (parabola, etc.) of the curve. The curves in Figure 7.1 show two noteworthy differences from "normal" vapor pressure curves.

1) The fluorine vapor pressure over the two different water samples from Pond 10 is not significantly

Table 7.1 Vapor pressure over pond water from Pond 10 containing .628 gmoles/L (11.9 g/L) fluorine

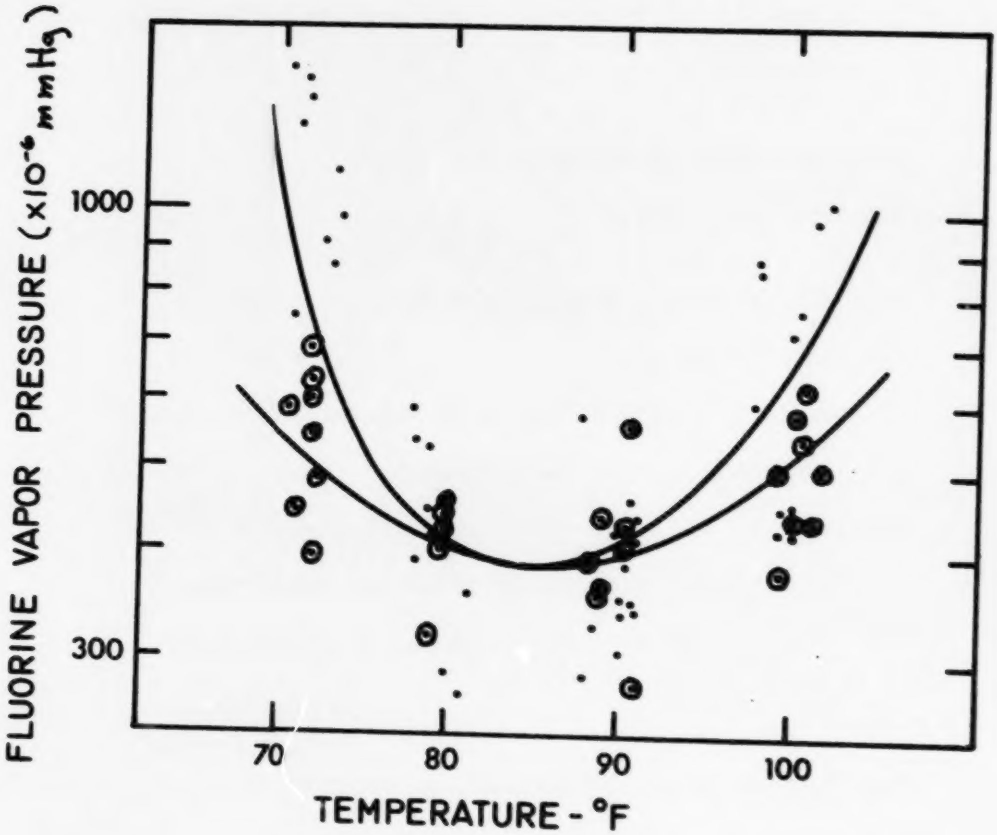
Temperature °F	Total Pressure mm Hg	Fluorine Partial Pressure (10^{-6} mm Hg)
69.2	14.72	1009
70.9	17.38	1424
71.3	17.70	907
71.8	18.08	980
71.7	19.64	850
70.7	18.04	1253
71.7	17.10	1132
80.5	26.28	266
80.7	26.42	353
79.5	25.99	443
79.3	25.35	383
79.2	25.50	540
79.0	25.44	585
89.0	34.75	571
90.6	37.12	435
90.5	37.08	337
89.5	35.35	180
89.3	35.12	328
89.0	35.07	283
90.0	36.33	302
90.2	36.46	388
90.2	36.72	349
90.3	36.69	344
98.9	47.50	584
99.0	45.57	843
99.0	45.45	861
100.0	49.12	711
100.0	49.26	442
100.0	49.36	420
99.8	49.25	418
99.7	48.93	445

Table 7.2 Vapor pressure of pond water from Pond 10 containing .800 gmoles/L (15.2 g/L) flourine

Temperature °F	Total Pressure mm Hg	Fluorine Partial Pressure (10^{-6} mm Hg)
69.8	17.73	627
70.5	18.42	748
70.8	18.71	1340
70.4	18.44	1454
80.0	25.72	283
79.7	25.69	413
79.5	25.71	527
90.4	33.15	458
90.6	33.48	414
89.8	33.08	418
100.2	48.86	758
101.0	49.11	1010
100.8	48.76	981

Table 7.3 Vapor pressure of pond water from Pond 20 containing .336 gmoles/L (6.19 g/L) fluorine

Temperature °F	Total Pressure mm Hg	Fluorine Partial Pressure (10^{-6} mm Hg)
71.0	18.85	391
70.6	18.63	438
71.0	18.73	625
71.0	18.81	595
71.0	19.08	694
70.5	18.35	596
71.0	19.06	534
71.2	19.33	478
79.5	25.90	315
79.5	25.53	437
80.0	26.09	406
79.8	26.08	422
80.9	26.57	455
90.5	35.44	275
90.4	35.82	428
90.2	35.54	424
90.4	35.74	557
98.5	34.91	367
89.5	35.00	438
89.7	34.76	359
89.1	34.47	388
100.8	48.84	469
100.6	48.70	428
100.3	48.58	530
100.1	48.03	437
100.3	48.96	614
99.7	48.10	497
100.1	48.50	569
99.9	47.84	384



• - Upper line - Pond 10

◉ - Lower line - Pond 20

Figure 7.1 Fluorine vapor pressure over pond water

different even though the fluorine content of the two samples differed - .628 g moles F/L and .800 g moles F/L .

2) The fluorine vapor pressure over water from both Ponds 10 and 20 have a common minimum in the range 80-90 °F.

Three potential explanations for either or both of these observations are possible:

1) entrainment or condensation occurred in the equilibrium still;
2) an inert fluorine containing species in the liquid phase was analyzed as soluble fluorine;
3) several different fluorine containing chemical species, not all equally volatile, are present in the water and are in complex equilibrium with each other.

The first of these explanations, entrainment and/or condensation, is certainly a potentially important effect since about 0.7 ml of either refluxed vapor or entrained liquid per liter of condensed vapor will cause a 50% variation in the measured vapor fluorine content. Entrainment and condensation were probably primarily responsible for the scatter in the experimental results: however, this error source was rejected as a possible explanation for the shape of the curve for two reasons:

1) The still and the operating technique produced satisfactory results with the $HF-H_2O$ system as documented in Appendix 15.3.

2) Changes in the vaporization rate at a given temperature did not result in corresponding variations in the measured fluorine vapor pressure. (Higher vaporization rates would be expected to cause higher entrainment rates which in turn would result in higher apparent fluorine vapor pressure.)

The difference in the fluorine concentration in the two liquid samples from Pond 10 may be due to a non-volatile, non-reactive fluoride species, such as fine particulate matter. If this is true, the vapor pressure curve for the two pond water samples can be expected to coincide. No work was done to demonstrate this postulate. However, during the vapor pressure studies a set of observations was made which lends some credence to the postulate. As shown in Figure 7.2, the apparent fluorine content of the three samples of pond water studied decreased slowly with time because of fluorine precipitation[7/]. The water samples were stored in five gallon, narrow mouth, polyethylene bottles with water-tight, screw lids

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[7/] Since the results shown in Figure 7.2 were not obtained from a planned experiment, the pond water temperature at the time of sampling was not closely controlled. As shown in a following paragraph, this uncontrolled variable may effect the conclusion to some extent.

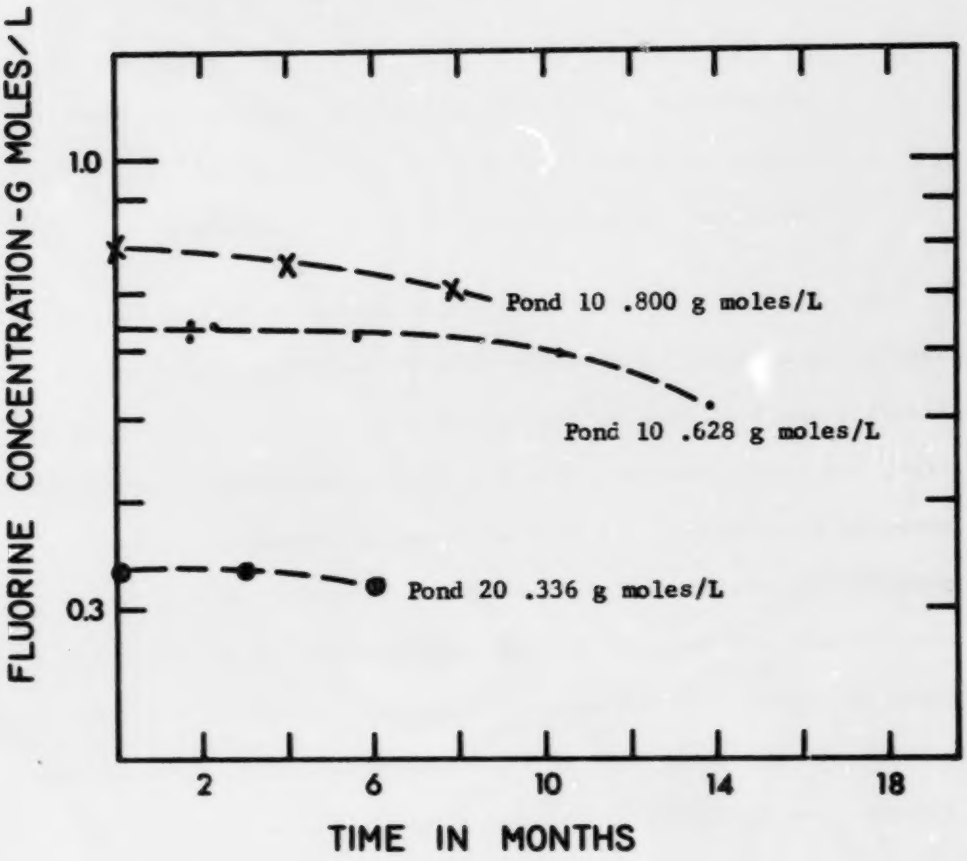


Figure 7.2 Variation of fluorine in pond water samples with time

at room temperature (estimated to average about 75 °F). Pond bottom solids were initially present in Pond 10, .628 g moles/L , and Pond 20 samples but not in Pond 10, .800 g moles/L sample. In this sample a hard, plate-like precipitate formed in the initially clean solution over a period of almost one month. Enough vapor pressure measurements were made on the pond 10, .628 g moles/L sample over a nine month period to demonstrate that the drop in pond water fluorine content did not cause a change in the fluorine vapor pressure.

To demonstrate the potential effect of a three-phase equilibrium between several fluorine containing species of unequal volatility a two reaction model was postulated.

$$H_2SiF_6 \overset{K_1}{\rightleftarrows} SiF_4 + 2HF\uparrow$$

$$X + SiF_4 \overset{K_T}{\rightleftarrows} X\ SiF_4\downarrow$$

The first reaction postulating that all fluorine vaporized is HF may be a reasonable assumption since Illarionov [13] measured a vapor phase HF/SiF_4 ratio of about 12 for a liquid phase concentration of 1.09% (weight) hydrofluosilicic acid in water. The second reaction, postulating the precipitation of a silicon tetrafluoride compound has no support in the literature.

The temperature dependency of the equilibrium constant, K_1 , for Pond 10 water was obtained from the experimental 70° F. data and the assumption that the Pond 10 curve has the same shape as the one calculated from Tatera's data on the system hydrofluosilicic acid - water. The hydrogen fluoride content of Pond 10 water was estimated by comparing the fluorine vapor pressure over it with the $HF-H_2O$ system. Figure 7.3 shows the estimated ionization constant for Pond 10 water as a function of temperature.

In order to determine the change of fluorine content with temperature, samples of Pond 10 water with pond bottoms present were held in tightly closed polyethylene bottles at a constant temperature for 24 to 48 hour periods. The aqueous phase was then analyzed for total fluorine content. The results of these experiments, shown in Figure 7.4, were used to estimate the change in the SiF_4 content of the pond water. Substituting the information in Figures 7.3 and 7.4 and the stoichiometric equation into the equilibrium Equation (40)

$$K_i = \frac{(HF)^2(SiF_4)}{(H_2\ SiF_6)} \tag{40}$$

where

K_i = from Figure 7.2

$(SiF_4) = (\frac{HF}{2} + \frac{\Delta F_{T-70}}{4})$

HF/2 = from stoichiometric relation

$\frac{\Delta F_{T-70}}{4}$ = excess SiF_4 - increase in total fluorine concentration over 70° concentration from Figure 7.3 divided by 4

$(H_2SiF_6) = (\frac{F_T}{6} - \frac{HF}{2} - \frac{\Delta F_{T-70}}{4})$

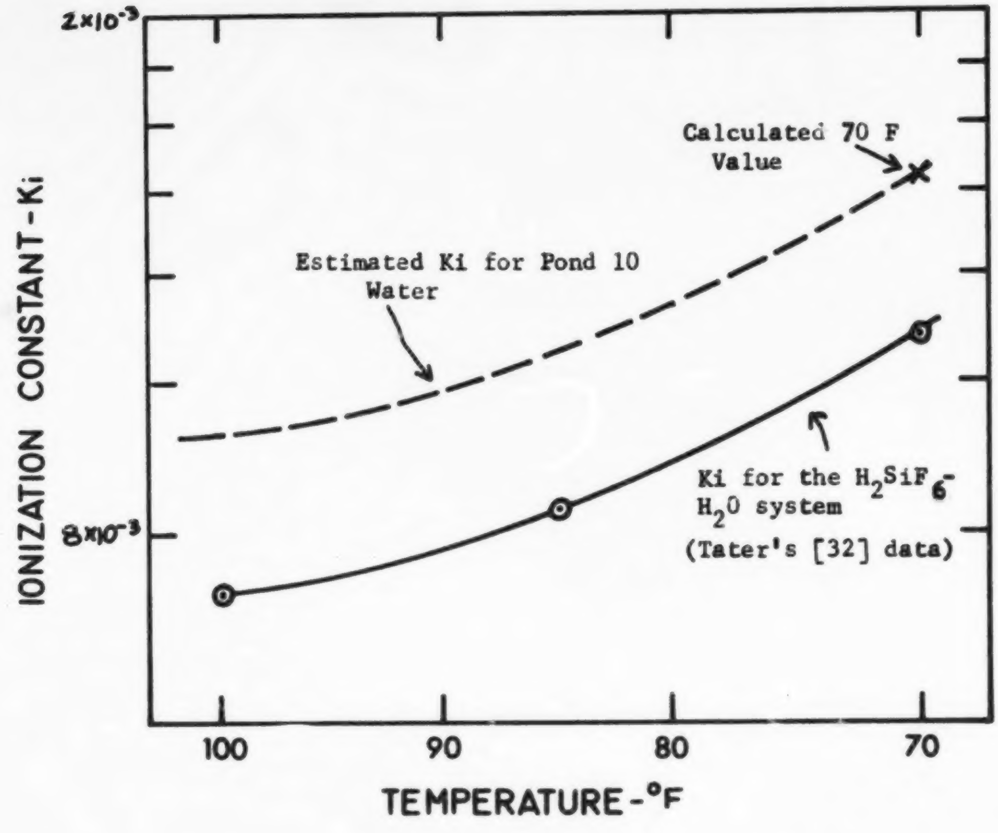


Figure 7.3 Ionization constant versus reciprocal temperature

$$Ki = \frac{[HF]^2[S_iF_6]}{[H_2{}^9,F_4]}$$

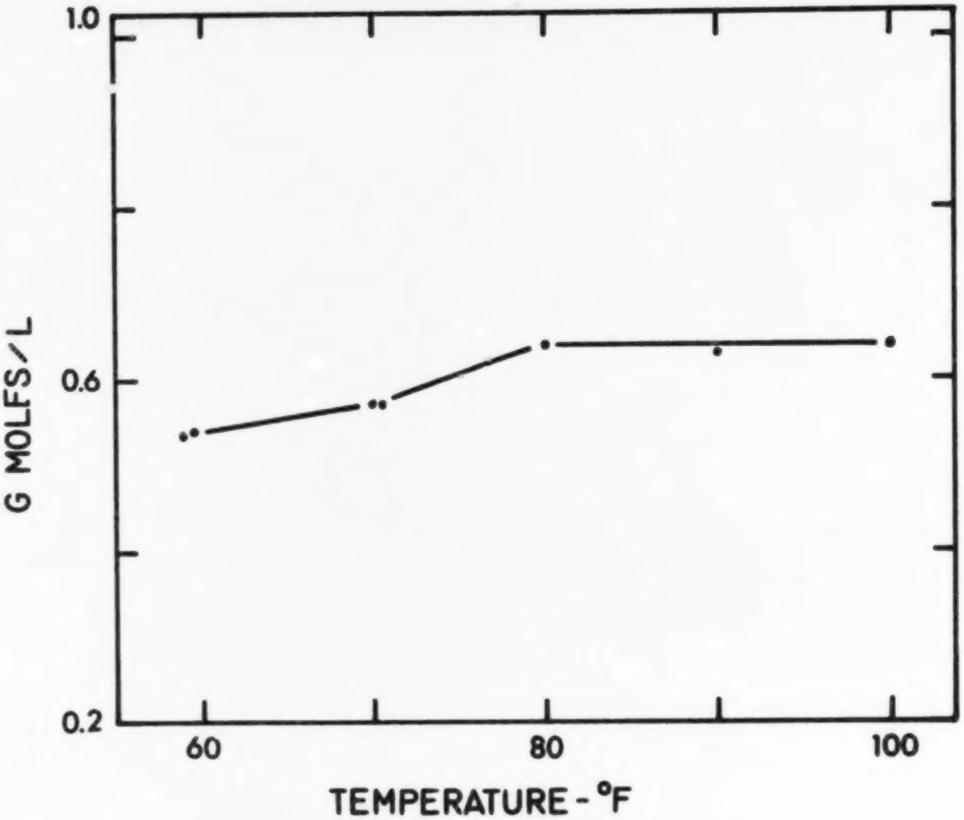


Figure 7.4 Solubility of fluorine in Pond 10 water as a function of temperature

F_T = total fluoride concentration at temperature T

yields a relation with the concentration of HF as the only unknown. Solving the equation yields an estimate of the liquid phase HF concentration; from this, the vapor pressure of fluorine can be estimated. Figure 7.5 compares the measured Pond 10 fluorine vapor pressures with the calculated values. Although the agreement is not good, the calculated curve has all the trends of the measured curve:

1) a decrease in the fluoride vapor pressures from 70 to 80 F
2) little or no change in vapor pressure between 80 and 90 F
3) an increase in vapor pressure between 90 and 100 F .

A further test of the two reaction model was made by calculating a fluorine vapor pressure curve for the diluted pond water Tatera studied. For his system K_i was assumed to be the same as the Pond 10 water K_i . Since dilution destroyed the solid-liquid equilibrium, ΔF_{T-70} was set equal to zero. Figure 7.6 shows that the calculated curve duplicates the experimental curve without using any of Tatera's pond water - H_2SiF_6 data for curve adjustment.

Fluorine content of the two pond waters studied in this work is representative of the fluorine content of the ponds samples as shown in Table 7.4. This fact coupled with the relative insensitivity of fluorine vapor pressure to aqueous phase fluorine content leads this writer to believe that the vapor pressures measured in this study can

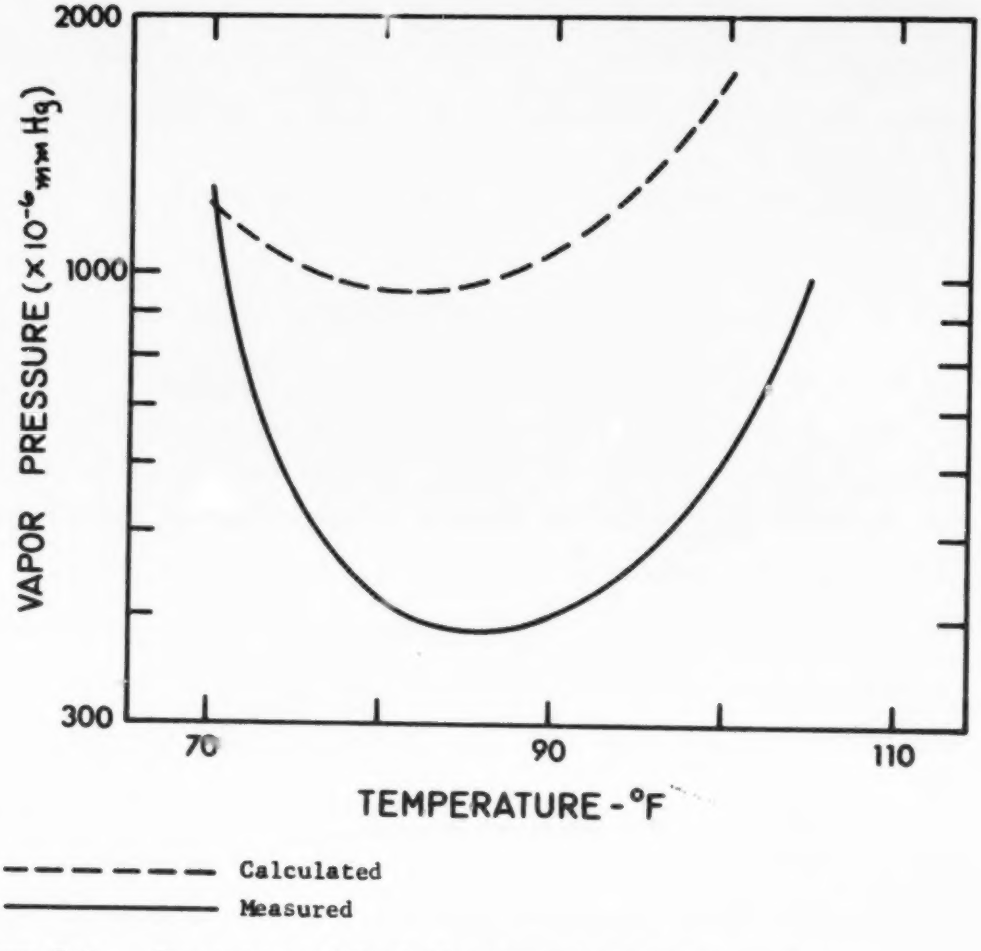


Figure 7.5 Comparison of Pond 10 calculated and measured vapor pressure curves

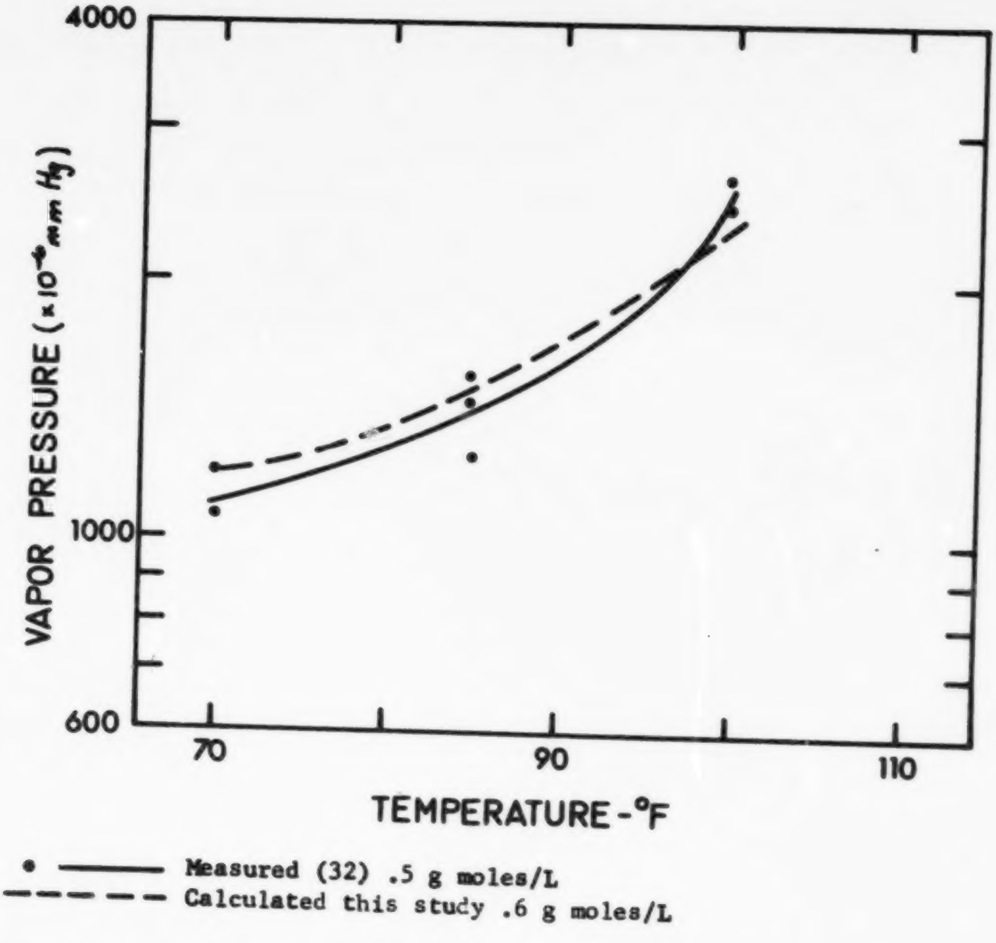


Figure 7.6 Comparison of calculated and measured vapor pressure curves for a mixture of diluted pond water and hydrofluosilicic acid

Table 7.4 Pond water fluorine content of different wet-process acid plants

Plant	Fluorine Concentration gmoles/L
10	.628
20	.336
30	.264
40	.338
50	.202

be used in the production of accurate emission estimates for most ponds.

7.3 Vapor Liquid Equilibrium Still

7.3.1 Design, Operation and Accuracy

The major considerations that influenced the choice of apparatus used to measure the fluorine-pond-water, vapor-liquid equilibrium are listed below:

1) Since there is an apparent fluorine interchange between the pond bottom and the aqueous phase, a pond water-bottoms slurry will be charged to the still. The apparatus must be able to handle a slurry.
2) The equilibrium relationships in the pond water system should be disturbed as little as possible; therefore, the liquid phase must be much larger than the condensed vapor phase.
3) The volatility of fluorine in pond water is small; therefore, entrainment and condensation must be avoided. A dynamic system if used must handle large quantities of gas.
4) Pond water is acid (Ph 1.5); it contains fluorine in a form corrosive to glass. Corrosion resistant materials of construction must be utilized.
5) If a large volume of liquid is used, thermal gradients within the liquid must be minimized.

6) The still should be relatively easy to construct and operate.

Based on these considerations, the modified Othmar still shown in Figures 7.7 and 7.8 was constructed from glass. All surfaces in contact with liquid or vapor were coated with a 70°C melting point paraffin wax. Neither the coated glass nor the wax coating showed any signs of corrosion. The surface of the armored thermocouple was slightly attacked during the experimental work.

The distillation head was insulated with about 1/16" of glass wool; a 300 watt heating tape was wound over this and both layers were covered with 1/8" layer of glass wool. The head skin-temperature was maintained about 30°F above the boiling flask temperature as monitored by a mercury-in-glass thermometer inserted between the first layer of glass wool and the heating tape. Enough superheat was imparted to the rising vapors that no condensation was observed in the vapor line.

System pressure was maintained and controlled by a Cartesian manostat coupled to a vacuum pump. A hypodermic needle was placed in the vacuum tubing after the condenser to provide the air flow necessary for the smooth operation of the manostat. Pressure drop across the manostat could be controlled to ± .15 mm Hg . The differential pressure across the manostat was measured with a butylphthalate filled manometer; the low-pressure-side pressure was measured with a McLeod Gauge. The McLeod Gauge in the normal operating range could be read to .1 mm Hg; the manometer to .15 mm Hg . The total

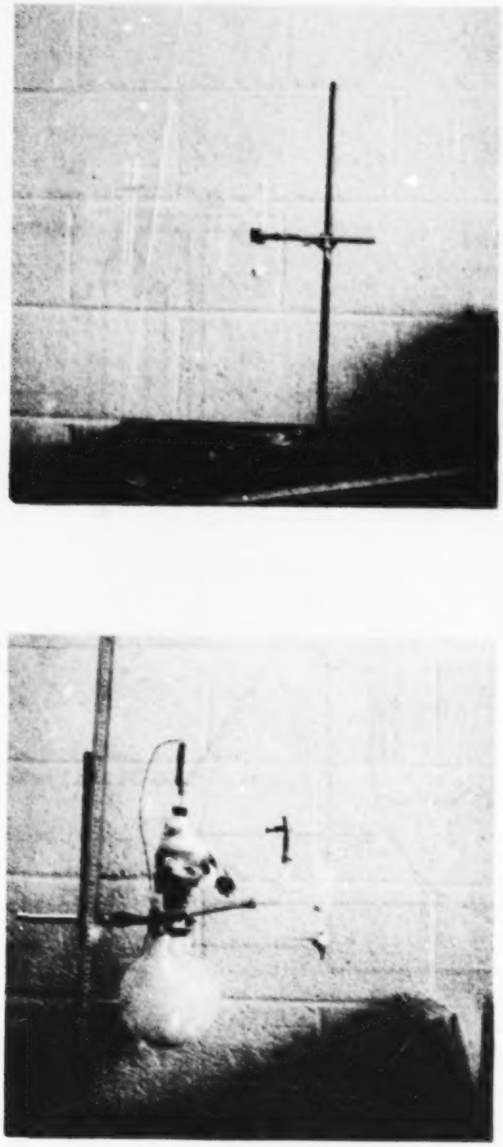


Figure 7-7 Photos of still used in vapor liquid equilibrium studies

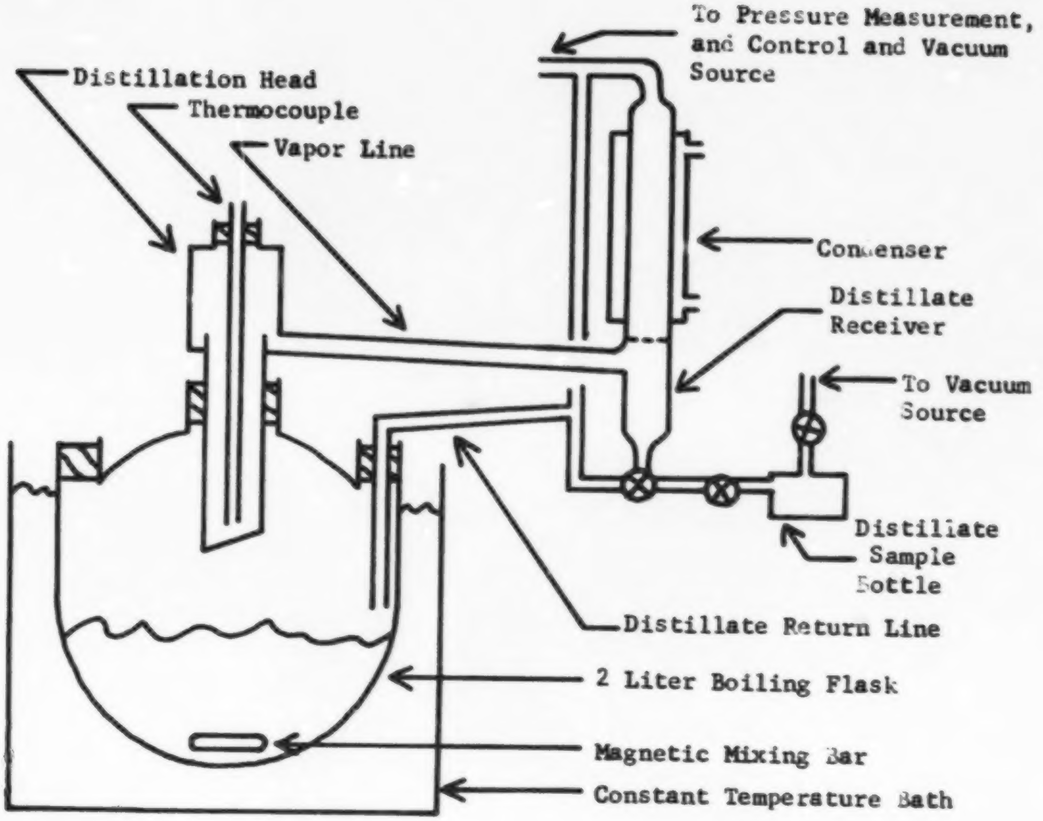

To Pressure Measurement, and Control and Vacuum Source
Distillation Head
Thermocouple
Vapor Line
Condenser
Distillate Receiver
To Vacuum Source
Distillate Sample Bottle
Distillate Return Line
2 Liter Boiling Flask
Magnetic Mixing Bar
Constant Temperature Bath

Figure 7.8 Sketch of still for vapor-liquid equilibrium measurements

pressure in the equilibrium still ranged from 17 to 50 mm Hg . Still temperatures could be measured within 0.5° F with the copper-constantan thermocouple and available potentiometer. The thermocouple was calibrated against thermometers constructed to ASTM E-1 specifications; the thermocouple's voltage versus temperature curve was not significantly different than tabled values [29]. Operating temperatures were 70-100° F.

An experimental study was begun by thoroughly cleaning the apparatus and repairing any wax damage. 1600 ml of pond water containing a small amount of pond bottoms was charged to the boiling flask. The mixture was thoroughly agitated with the magnetic mixing bar and a 20 ml sample was withdrawn for later analysis (all samples were stored in polyethylene bottles with air tight screw tops.) The still-thermocouple and the appropriate ASTM thermometer were immersed in the constant temperature bath which was at room temperature. The thermocouple voltage output was compared with the calibration curve. The thermocouple was then placed into the apparatus so that its tip was 1-2 inches above the bottom edge of the distillation head and 3-4 inches above the stirred liquid level. The head heating tape was activiated and the condenser cooling water flow was started. Cooling water temperature was maintained about 20° F below the boiling flask temperature. The vacuum pump was started with the manostat pressure differential set at a high value and the by-pass on the manometer opened. When the total system pressure dropped to about 75 mm Hg , the manometer bypass was shut. The manostat and the controlled leak were set such that the total pressure in the still was about the desired pressure and the pressure as measured by the McLeod Gauge was about 3 mm Hg. (This later pressure was found by experience to give smooth manostat operation without straining the vacuum pump's capacity.) The bath temperature was held constant at about 3° F higher than the desired still temperature. The experimental overall heat transfer coefficient for this apparatus was about 41 BTU/hr ft^2 F ; a 3°F driving force resulted in a boil-up rate of about 40 ml/hr. Since the operating volume of the distillate receiver was between 10 and 20 ml; the boil-up rate is equivalent to 2 to 4 turnovers/hr.

The intent of the program was to collect data at 70, 80, 90, and 100°F; however, the system pressure adjustment equivalent to less than 1° F was tedious; the result is a band of data around each design temperature.

After the still had been operating steadily for about 3 hours (2 hours for subsequent samples at the same still temperatures), about 10 ml distillate samples were removed by manipulation of the three way valve on the distillate receiver and the valves on the previously evacuated distillate sample bottle. (Distillate samples were stored for later analysis in polyethylene bottles). Since evacuating the distillate receiver normally resulted in a 1 mm Hg pressure surge, it was always placed into the system before beginning to measure the steady state time lapse.

7.3.2 Demonstration of the Still's Capability to Produce Thermodynamically Consistent Data

Normally the quality of vapor-liquid equilibrium data is demonstrated by testing measurements over a range of liquid phase concentrations for thermodynamic consistency. However, pond water composition could not be varied (see Section 7.2). As an alternative to the rigorous thermodynamic tests, the assumption was made that the production of consistent data for the hydrogen fluoride water ($HF-H_2O$) system would demonstrate that the still and operating techniques would produce good quality results for the pond water-fluorine system. The $HF-H_2O$ system was chosen because hydrogen fluoride in water is a relatively non-volatile material like the fluorine compounds in pond water. In addition it is chemically corrosive and can be analyzed in the same way as fluorine in pond water. Therefore, materials of construction and analytical methods could be tested along with the still and operating technique.

The work on the $HF-H_2O$ system showed that the still could produce equilibrium measurements consistent with thermodynamic criteria and the correlations developed from published data. The details of this study are reported in Appendix 15.3.

8. AMBIENT AIR MEASUREMENTS

8.1 Summary

One hundred thirty two ambient air samples were obtained at two pond sites. Ninety five of these were usable in the study. Appendix 15.5 lists the unusable samples along with justification for discarding them. Air stability categories ranged from 1 to 5[8/] and wind speeds, measured at three meters above the ground, ranged from .9 to 6.3 meters/second. Pond water temperatures ranged from 80 to 100°F. Measured ambient air fluorine concentrations, in the usable runs, ranged from 0.15 to 4.15 x 10^{-6} g moles/cubic meter. The individual run analysis of the usable samples are catalogued in Appendix 15.4.

8.2 Data Collected

In addition to obtaining the ambient air fluorine samples, the following measurements and observations were made in the field.

1) Wind speed at 3.05 meters (continuous record)
2) Wind direction at 3.05 meters (continuous record)
3) Wet bulb and dry bulb air temperature (one per hour)
4) Atmospheric condition (cloud cover, radiation intensity, etc.) (one per hour)

[8/] Air stability classifications used in this study are defined in the program listing in Appendix 15.7 and in Turner [26, p. 7]. However, the later reference identifies the stability categories as A, B, etc. rather than 1, 2, etc.

5) Air stability estimate (one per hour)

6) Pond water inlet and outlet temperature (one to four times per day)

7) Pond water fluorine concentration (one per day) .

8.3 Pond Descriptions

8.3.1 Pond 10

Pond 10 is a nomial 100 acre, roughly rectangular cooling pond. Figure 8.1 is a sketch of the pond showing the sampler locations; Figure 8.2 shows photos of the pond. The fertilizer complex is 300 to 400 meters northeast of the pond. No other identified sources of fluorine emissions are closer than several kilometers. The land beyond the southeast and southwest edges of the pond is grass covered for at least 300 meters, generally flat, and the same height as the pond water. Beyond the surrounding grass, the land is flat and tree covered. The pond banks are dikes about 2 meters above the water level except the stretch around the 01 and 02 sampling sites. The finger separating the pond into hot and cold sides is about the same height as the dikes. Gypsum piles about 15 meters tall border the northwest and part of the northeast sides of the pond. Gypsum was not being accumulated on the northwest pile during the test period and the gypsum disposal ponds on top of the pile were dry. The northeast pile was used for gypsum disposal. A gypsum pond of perhaps 50 acres occupied the top of the pile. The area around sampler 01 and 02 slopes generally upward from water level to about 8 meters above water

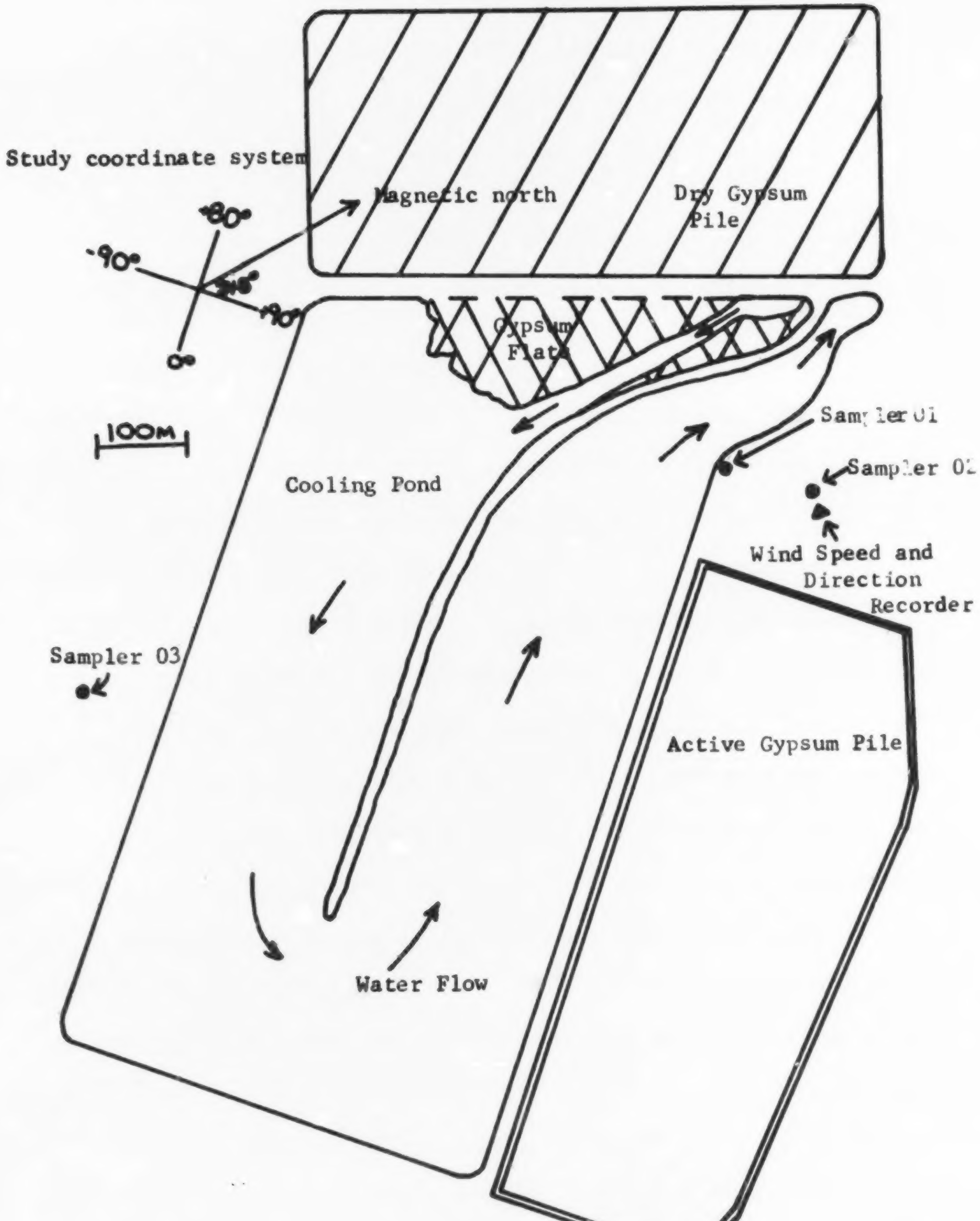
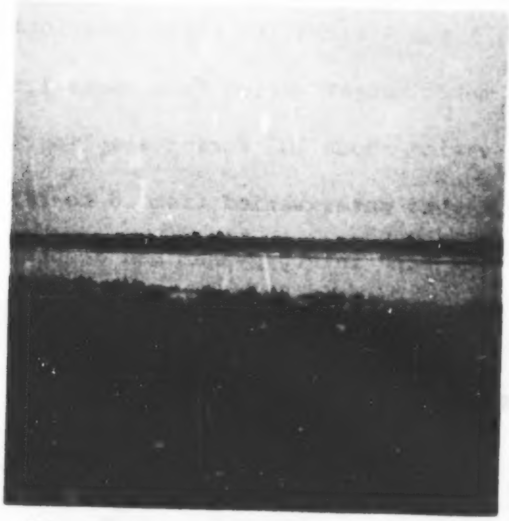

Study coordinate system
Magnetic north
Dry Gypsum Pile
180°
-90°
45°
+90°
0°
Gypsum Flats
100M
Sampler 01
Sampler 02
Cooling Pond
Wind Speed and Direction Recorder
Sampler 03
Active Gypsum Pile
Water Flow

Figure 8.1 Pond 10 plot sketch

View along north west side of pond from sampler site 01



View across pond from sampler site 02

Figure 8-2 Photos of pond 10.

level at 100 meters from the shore and then downward toward the plant. Sampler 01 was set 10 meters from the edge of the pond. Its base was 0.0 meters above water level. Sampler 02 was set 100 meters inland from 01 on a line perpendicular to the northeast shore line; the base of the sampler was about 6.5 meters above the water level due to the land rise. The wind speed and velocity measurement sensors were about 110 meters from the edge of the pond at the crest of the rise. The base of the unit was 8 meters above the pond water level.

Sampler 03 was set 100 meters beyond the southwest pond edge on the dike between two dry, limed-pond-water holding ponds. The base of the sampler was about 2 meters above pond level.

During sampling, winds were usually southerly. Overcast skies and squalls were common; 3 and 4 stability classifications predominated. Wind speed at the 3 meter height varied from about 1.5 to 6.3 meters/sec.

The pond level varied about 10% during sampling. Fluorine concentrations in the pond water varied from .8 to .95 g moles/L.

Around the cooling pond inlet, gypsum had dropped out of the cooling water forming wet flats. The top surface of these flats were typically less than a meter above the pond surface. Water circulation rate through the pond was a nominal 33,000 gallons/minute.

8.3.2 Pond 20

Pond 20 is a 160 acre irregularly shaped cooling pond constructed on an old mine site. Figure 8.3 is a sketch of the pond; Figure 8.4 shows photos of the site. The phosphate fertilizer manufacturing complex is directly south of the pond. The gypsum disposal area is on

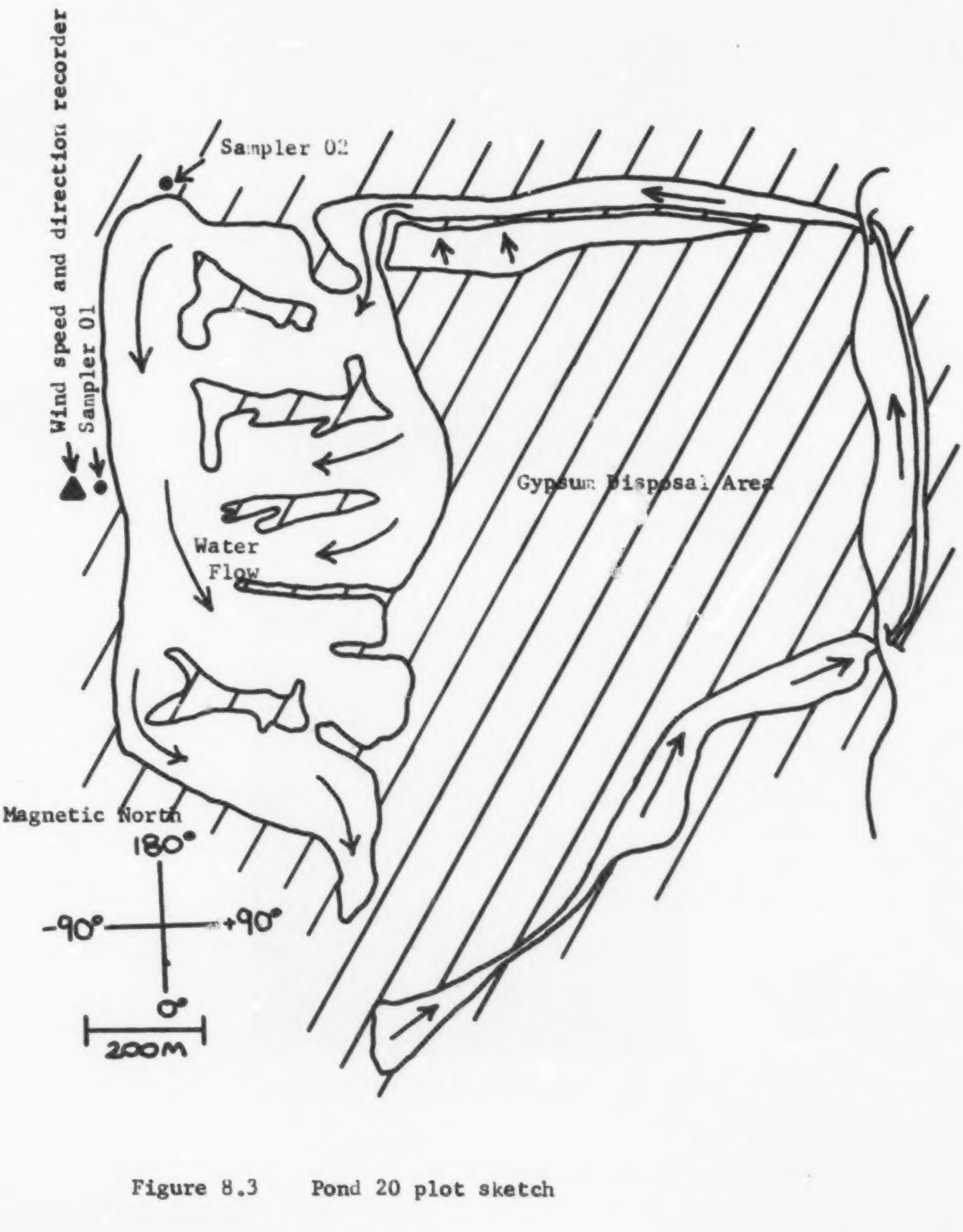
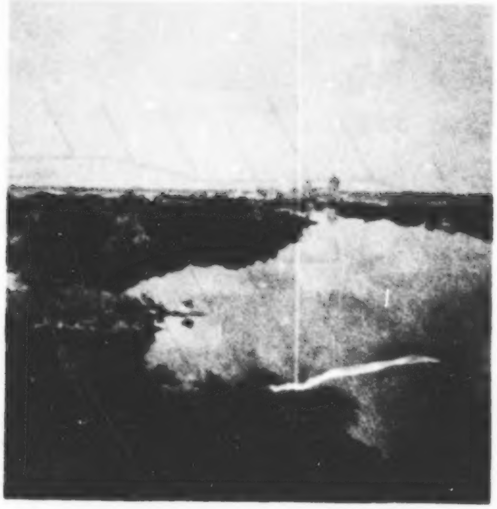
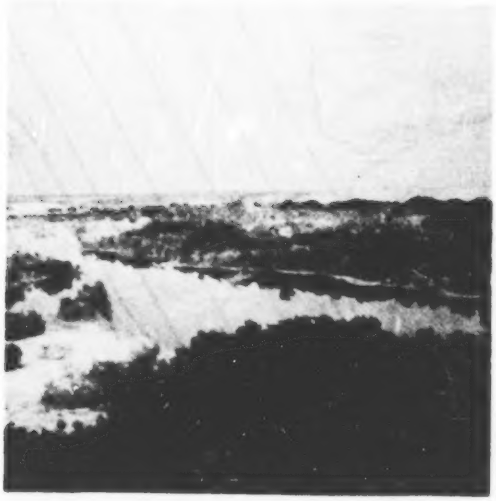

Wind speed and direction recorder
Sampler 01
Sampler 02
Water Flow
Gypsum Disposal Area
Magnetic North
180°
-90°
+90°
0°
200M

Figure 8.3 Pond 20 plot sketch



View south from site 02



View east from site 02

Figure 8-4 Photos of pond 20.

the land mass in the center of the pond. A secondary holding pond for limed pond water is just north of the cooling pond. Since the fluorine content of this pond was about 5% that of the cooling pond, the assumption was made in the data analysis that the emissions from this secondary pond were zero. No other known source of fluorine emissions is closer than about 4 kilometers. The terrain in all directions is flat. The level of the pond was less than one meter below the edge of the banks. Small weed trees, 2 to 3 meters tall, cover the edge of the pond bank although at least 15 meters of grass covered ground surrounded each sampler. Sampler 01 and the wind speed and direction measuring devices were set at about the midpoint of the pond's west edge, 21 meters west of the pond. Sampler 02 was set along the northern edge of the pond about 75 meters east of the northeast corner and 20 meters north of the pond.

During the period of sampling, winds usually blew from the east. Sunny skies and 1 and 2 stability classifications were common during actual sampling. However, rain squalls frequently occurred in the late afternoon and inversions were common in the early morning. Wind speed at 3 meters varied from 0.9 to 3.5 meters/sec.

Pond levels remained constant during sampling. Pond water fluorine levels varied from .34 to .47 g moles/L and seemed to be a function of the amount of rainfall.

Water circulation rate through the pond was a nominal 20,000 gallons/minute.

8.4 Sampler, Sample Recovery and Sample Analysis

The sampler shown in Figures 8.5 and 8.6 has a capture element similar to the one used in the automatic "HF Gas Analyzer" manufactured by the Denki Kagaku Kecki Co., Ltd., Tokyo, Japan. The Environmental Protection Agency evaluated this analyzer and concluded that a 15 foot tube length was sufficient to capture hydrogen fluoride quantitatively. However, the laboratory tests performed in this study showed a single, 15 foot unit recovered only 85% of the pond water gaseous fluorine emissions from the ambient air. Two 15 foot tube lengths connected in series recovered 95% of the ambient air fluorides in laboratory tests. Calculations indicated that three units in series might be expected to recover 99+%. As Figures 8.4 and 8.5 show, two capture elements in series were chosen as the optimum balance between recovery and field portability. Appendix 15.6 contains a detailed discussion of the experimental efficiency studies on the ambient air sampler.

The air sampling rate was about 30 liters/minute which resulted in a total one hour sample of about 1.8 m^3. The fluorine content of the air sample was captured in about 30 ml of 2 g/L Na_2CO_3 solution. The liquid fluorine content was analyzed as described in Chapter 6. The standard sampler field operating procedure and the standard sample recovery procedure are also included in Appendix 15.6.

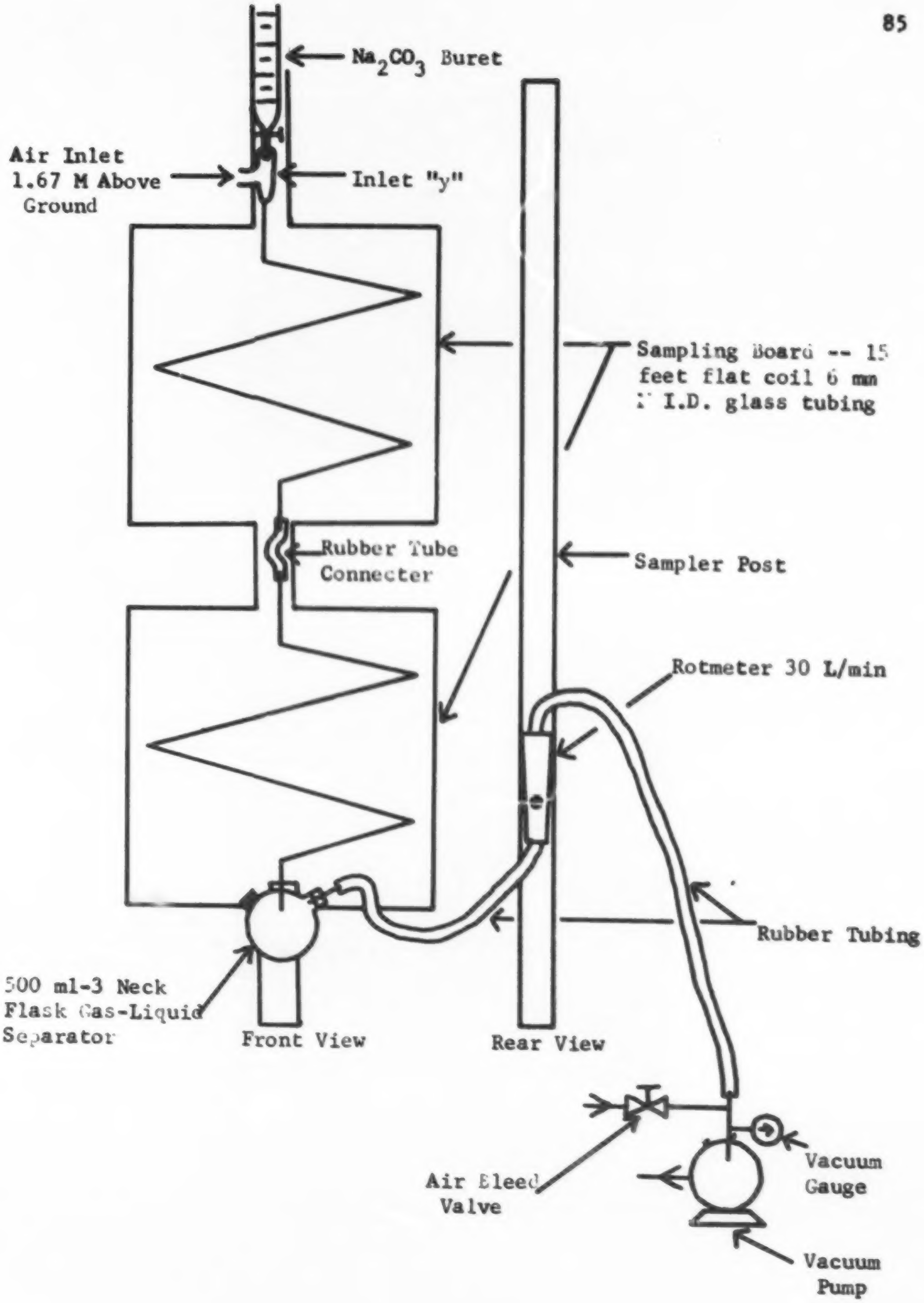
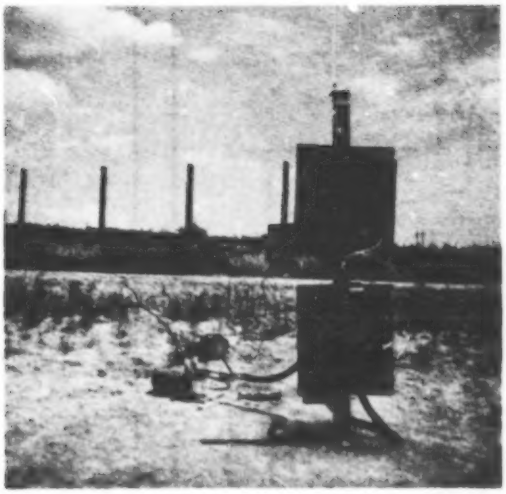
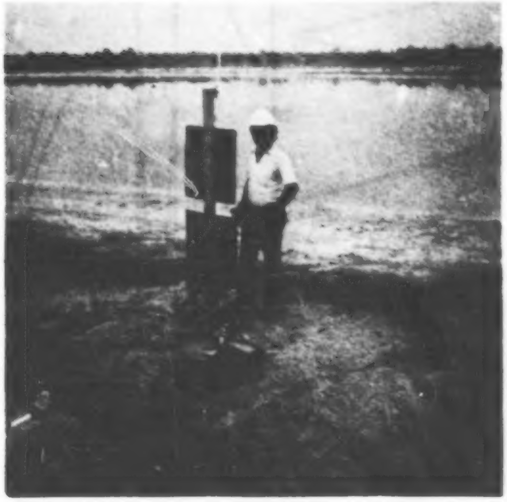

Na_2CO_3 Buret
Air Inlet 1.67 M Above Ground
Inlet "y"
Sampling Board -- 15 feet flat coil 6 mm I.D. glass tubing
Rubber Tube Connecter
Sampler Post
Rotmeter 30 L/min
Rubber Tubing
500 ml-3 Neck Flask Gas-Liquid Separator
Front View
Rear View
Air Bleed Valve
Vacuum Gauge
Vacuum Pump

Figure 8.5 Ambient air sampler



Sampler - front view



Sampler - rear view

Figure 8-6 Photos of ambient air samples

9. COMPUTER SIMULATION OF POND EMISSIONS AND AMBIENT AIR CONCENTRATIONS

9.1 Simulation Concepts

The computer simulation described in this section develops an estimate of the ambient air fluorine concentration that a field sampler downwind of a pond would register under a given set of atmospheric conditions. The program considers the period of time during which a single field sample (Chapter 8) was obtained. For this period it combines the pond-water fluorine vapor pressure (Section 7.2) with the mass transfer coefficient (Section 4.8) and the wind speed profile estimate (Chapter 5) to produce an emission estimate for the pond. This estimate is further combined with field measurements of wind speed and direction, pond-sampler geometric relationships and atmospheric stability estimates in a standard atmospheric pollutant dispersion estimate. The result of the calculation sequence is an estimated average ambient air fluorine concentration at the sampler over the time period that an actual sample was gathered.

The program simulates a pond as a maximum of 10 multisided (10 maximum), isothermal segments. The sampling time in the simulation is divided into 8 or less time periods. (Time periods of ten minutes or less were used in this report since the vertical and horizontal dispersion coefficients in the program are based on short period observations [26, p. 40-41].) For each time period each pond segment is oriented with respect to the wind and broken down into 10 meter wide strips as measured in the direction of the wind. Each strip is treated as a finite line source [26, p. 40-41]; its contribution to the total estimated concentration at the sampler is calculated from the equation

$$C(X,0,Z,0) = \frac{2q}{\sqrt{2\pi}\,\sigma_z u_s} \exp\left[-\frac{1}{2}\left(\frac{Z}{\sigma_z}\right)^2\right] \cdot$$

$$\int_{y_2/\sigma_y}^{y_1/\sigma_y} \frac{1}{\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] d\left(\frac{y}{\sigma_y}\right) \qquad (41)$$

where

$C(X,0,Z,0)$ = concentration at the sampler X meters from the pond strip and Z meters above ground level,

q = pond strip emission rate/unit width,

$\sigma_z \sigma_y$ = vertical and horizontal dispersion coefficients,

y_1, y_2 = cross wind edges of the pond strip,

u_s = wind speed at sampler height, and

Z = sampler height.

Within a time period the contribution of all strips are summed to produce the segment's contribution to the concentration at the sensor and all segments are summed to produce the predicted concentration at the field sampler. The time average concentration is then calculated from the equation

$$\bar{C}(X,0,Z,0) = \frac{\sum_{i=1}^{N'} \theta_i [C(X,0,Z,0)_i]}{\sum_{i=1}^{N'} \theta_i}$$

where

θ_i = length of time period i ,

$C(X,0,Z,0)_i$ = fluorine concentration at sampler during time period i ,

$\bar{C}(X,0,Z,0)$ = predicted time average fluorine concentration at the sampler, and

N' = number of time periods.

Figure 9.1 is a flow sheet describing the computer simulation. The program is listed in Appendix 15.7.

9.2 Data Inputs

The data input format is shown in Table 9.1.

9.3 Output of the Simulation

Normally, the program output is the single data sheet shown in Table 9.2 which summarizes the program inputs and compares the measured and calculated fluorine concentrations at the sampler. If desired, each pond segment emission rate per unit area and concentration contribution at the sensor for each time period can also be printed. Print 2 is substituted for Print 1 in the Input Data Pack, Table 9.1. This printout is shown in Table 9.3.

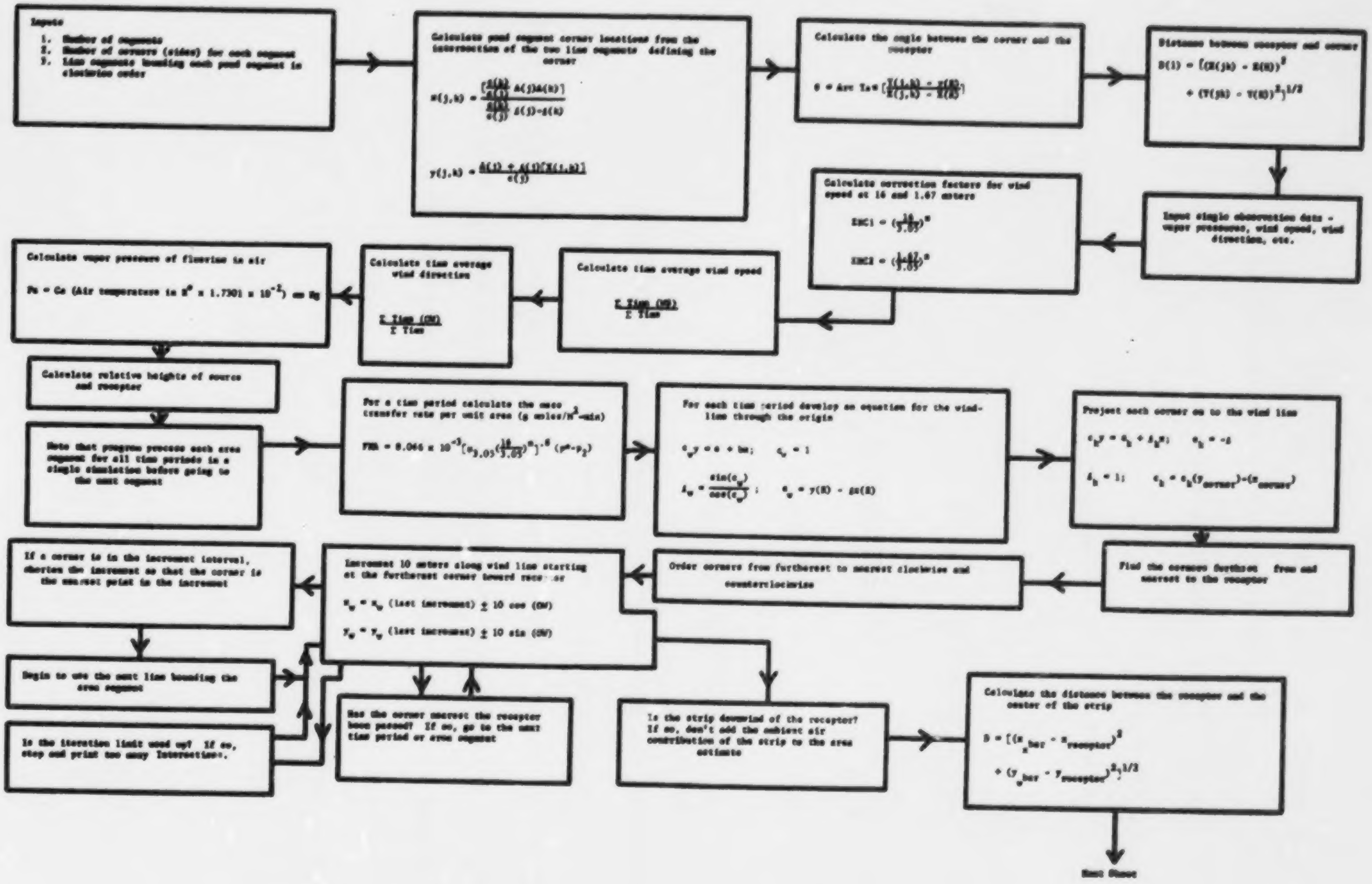

Inputs
1. Number of segments
2. Number of corners (sides) for each segment
3. Line segments bounding each pond segment in clockwise order
Calculate pond segment corner locations from the intersection of the two line segments defining the corner
Calculate the angle between the corner and the receptor
θ = Arc Tan
Distance between receptor and corner
Input single observation data - vapor pressures, wind speed, wind direction, etc.
Calculate correction factors for wind speed at 16 and 1.67 meters
Calculate time average wind speed
Σ Time (WS) / Σ Time
Calculate time average wind direction
Σ Time (DW) / Σ Time
Calculate vapor pressure of fluorine in air
Calculate relative heights of source and receptor
Note that program process each area segment for all time periods in a single simulation before going to the next segment
For a time period calculate the mass transfer rate per unit area (g moles/M²-min)
For each time period develop an equation for the wind-line through the origin
Project each corner on to the wind line
Find the corners furthest from and nearest to the receptor
Order corners from furtherest to nearest clockwise and counterclockwise
Increment 10 meters along wind line starting at the furtherest corner toward receptor
x_w = x_w (last increment) ± 10 cos (DW)
y_w = y_w (last increment) ± 10 sin (DW)
If a corner is in the increment interval, shorten the increment so that the corner is the nearest point in the increment
Begin to use the next line bounding the area segment
Is the iteration limit used up? If so, stop and print too many Interactions.
Has the corner nearest the receptor been passed? If so, go to the next time period or area segment
Is the strip downwind of the receptor? If so, don't add the ambient air contribution of the strip to the area estimate
Calculate the distance between the receptor and the center of the strip
Next Sheet

Figure 9.1 Pond simulation - ambient air concentrations downwind

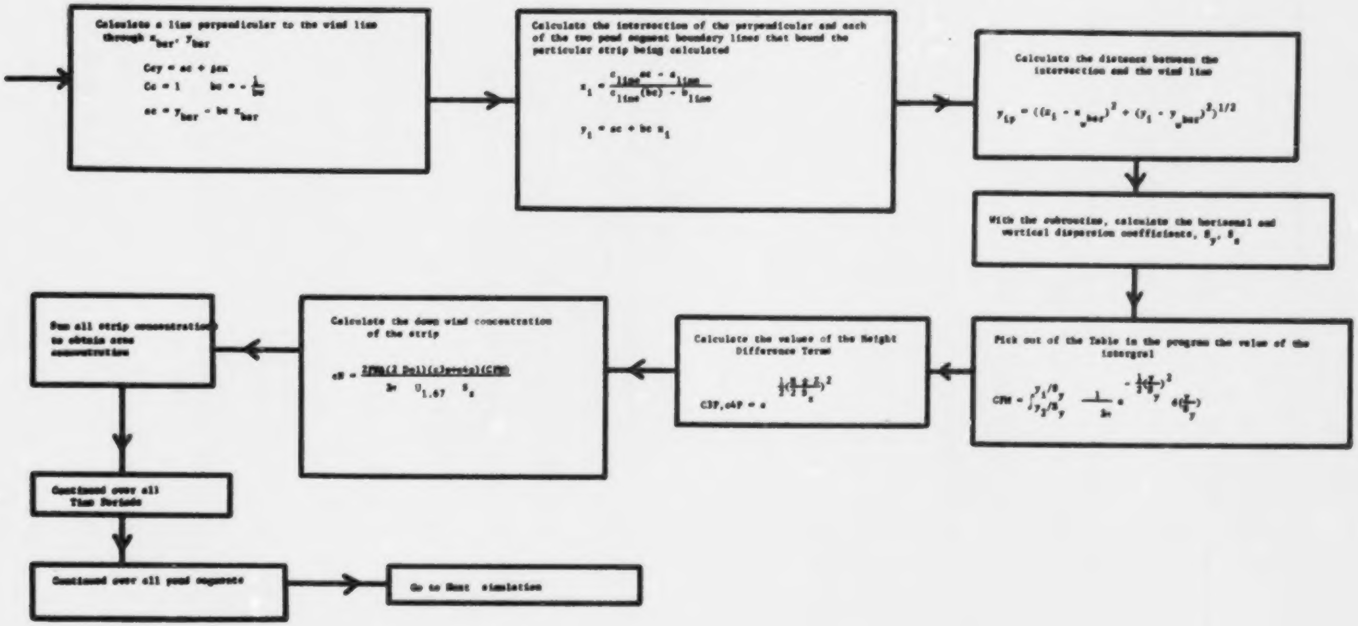

Calculate a line perpendicular to the wind line through x bar, y bar
Cey = ac + bcx
Cc = 1   bc = - 1/bw
ac = y bar - bc x bar
Calculate the intersection of the perpendicular and each of the two pond segment boundary lines that bound the particular strip being calculated
y1 = ac + bc x1
Calculate the distance between the intersection and the wind line
With the subroutine, calculate the horizontal and vertical dispersion coefficients, Sy, Sz
Pick out of the Table in the program the value of the intergral
Calculate the value of the Height Difference Term
Calculate the down wind concentration of the strip
Sum all strip concentrations to obtain area concentration
Continued over all Time Periods
Continued over all pond segments
Go to Next simulation

Figure 9.1 (Continued)

Table 9.1 Input format for simulation of ambient air concentration downwind of ponds

Card Number/ Spaces Used	Item Described
1/1-5	Maximum allowable number of strip calculations within a pond segment (program misexecution proctection)
1/6-10	Number of isothermal segments that the pond is broken into (10 maximum)
1/11-15	X co-ordinate of receptor (meters)
1/16-20	Y co-ordinate of receptor (meters
2/1-5	Number of corners (sides) bounding an isothermal pond segment (i)
3/1-5 3/6-10	The coefficients of line segment (j) bounding pond segment (i); the order is F,G,H
3/11-15	$HY = F + GX$
	The total number of line segment cards must equal E. The line segment cards must be ordered in a clockwise fashion around the pond segment
	The sequence must be repeated for each pond segment
4/1-6	Print 1 indicates the output format
5/1-2	Pond location code (numeric)
5/2-4	Sampler (sensor) identity number (numeric)
5/5-12	Date (alpha-numeric)
5/13-24	Start of sample period (alpha-numeric)
6/1-8 etc.	Pond water vapor pressures written as B required y E ± Xx mm Hg
7/1-5 etc.	Pond water temperatures corresponding to vapor pressures cited in N (°F) -- B required
8/1-10	Measured concentration at sensor g moles F/M^3 written as y E ± Xx. This is also used as the ambient air fluorine concentration over the pond.

Table 9.1 (Continued)

Card Number/ Spaces Used	Item Described
8/11-20 8/21-30	Wet and dry bulb temperatures (°F)
8/31-40	Source height (meters)
8/41-50	Receptor height (meters)
8/51-55	Stability class (numeric)
8/56-60	Velocity lapse rate coefficient (numeric)
9/1-5	Number of time periods in a sample period (8 maximum)
10/1-2 etc.	Minutes in each time period (W required)
11/1-5 etc.	Wind speed in each time period at 3.05 meters (miles/hr) (W required)
12/1-5 etc.	Wind direction in each time period in degrees (W required)

Imputs I through Z may be repeated for additional estimates at the subject receptor for the subject pond

Table 9.2 Simulation output sheet

```
        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 02

DATE 6/28/73    START TIME 9:04 A.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  2   WIND VEL. PROFILE EXP.  0.2330
SKY CONDITION

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   17.16 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.6 M/SEC
AIR TEMPERATURE    79.5F DRY BULB   76.5F WET BULB -



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1               83.0              385.0E-06
   2               84.5              381.0E-06
   3               86.5              380.0E-06
   4               88.7              386.0E-06
   5               91.5              403.0E-06
   6               94.5              460.0E-06
   7               96.3              510.0E-06
   8               82.5              389.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      9.98700E-07 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      8.89864E-07 GRAM_MOLE_F
                  ACTUAL CUBIC METER
```

Table 9.3 Individual area-time period estimates

Row 1	Contribution of pond segment to calculated ambient air fluorine concentration at sensor during time period (g moles/m^3)
Row 2	Fluorine emission rate from pond segment during time period (g moles/m^2min)

```
              CTOT/FNA  TABLE

         T 1         T 2         T 3         T 4         T 5         T 6

AREA  0.49714E-06 0.28302E-06 0.43067E-06 0.50962E-06 0.50002E-06 0.48359E-06
  1   0.96890E-05 0.84769E-05 0.84769E-05 0.90880E-05 0.84769E-05 0.96890E-05

AREA  0.31180E-07 0.10494E-10 0.91347E-09 0.12714E-07 0.40023E-08 0.38708E-08
  2   0.95858E-05 0.83866E-05 0.83866E-05 0.89912E-05 0.83866E-05 0.95858E-05

AREA  0.12600E-10 0.0         0.0         0.0         0.0         0.0
  3   0.95600E-05 0.83641E-05 0.83641E-05 0.89670E-05 0.83641E-05 0.95600E-05

AREA  0.43301E-08 0.0         0.11613E-10 0.99182E-09 0.14920E-09 0.14430E-09
  4   0.97148E-05 0.84995E-05 0.84995E-05 0.91122E-05 0.84995E-05 0.97148E-05

AREA  0.14981E-06 0.21499E-08 0.24878E-07 0.10266E-06 0.55965E-07 0.54126E-07
  5   0.10153E-04 0.88831E-05 0.88831E-05 0.95234E-05 0.88831E-05 0.10153E-04

AREA  0.17519E-06 0.32760E-06 0.39197E-06 0.27547E-06 0.35327E-06 0.34167E-06
  6   0.11623E-04 0.10169E-04 0.10169E-04 0.10902E-04 0.10169E-04 0.11623E-04

AREA  0.20852E-09 0.55809E-07 0.14119E-07 0.13490E-08 0.48243E-08 0.46658E-08
  7   0.12913E-04 0.11297E-04 0.11297E-04 0.12112E-04 0.11297E-04 0.12913E-04

AREA  0.78498E-09 0.16105E-06 0.42848E-07 0.42137E-08 0.16351E-07 0.15813E-07
  8   0.97921E-05 0.85672E-05 0.85672E-05 0.91848E-05 0.85672E-05 0.97921E-05
```

10. VERIFICATION OF THE POND SIMULATION

10.1 Verification

The ninety five usable measurements of fluorine ambient air concentrations are tabulated on individual data summary sheets in Appendix 15.4. These sheets contain both the measured fluorine ambient air concentrations and the values predicted by the computer simulation described in Chapter 9. Figure 10.1 and 10.2 compare the measured and the predicted ambient air fluorine concentrations for each pond individually.

Equations of the form

$$(\text{Calculated}) = a^{v} + b^{v}\ (\text{measured}) \qquad (42)$$

were fit with least squares techniques to the data for each pond; the results are shown in Table 10.1. If the simulation is an accurate prediction of the ambient air concentration downwind of the pond, the expected form of Equation (42) is

$$(\text{Calculated}) = 0 + 1.0\ (\text{measured}).$$

The two tailed Student's t test was used to compare statistically the best estimates of a^{v} and b^{v} (Equation (42)) against the expected value of zero and one. These tests, summarized in Table 10.2, show that none of the best-estimate values of a^{v} or b^{v} are significantly different from the expected values at the 95% confidence level. That is, the calculated value of the ambient air

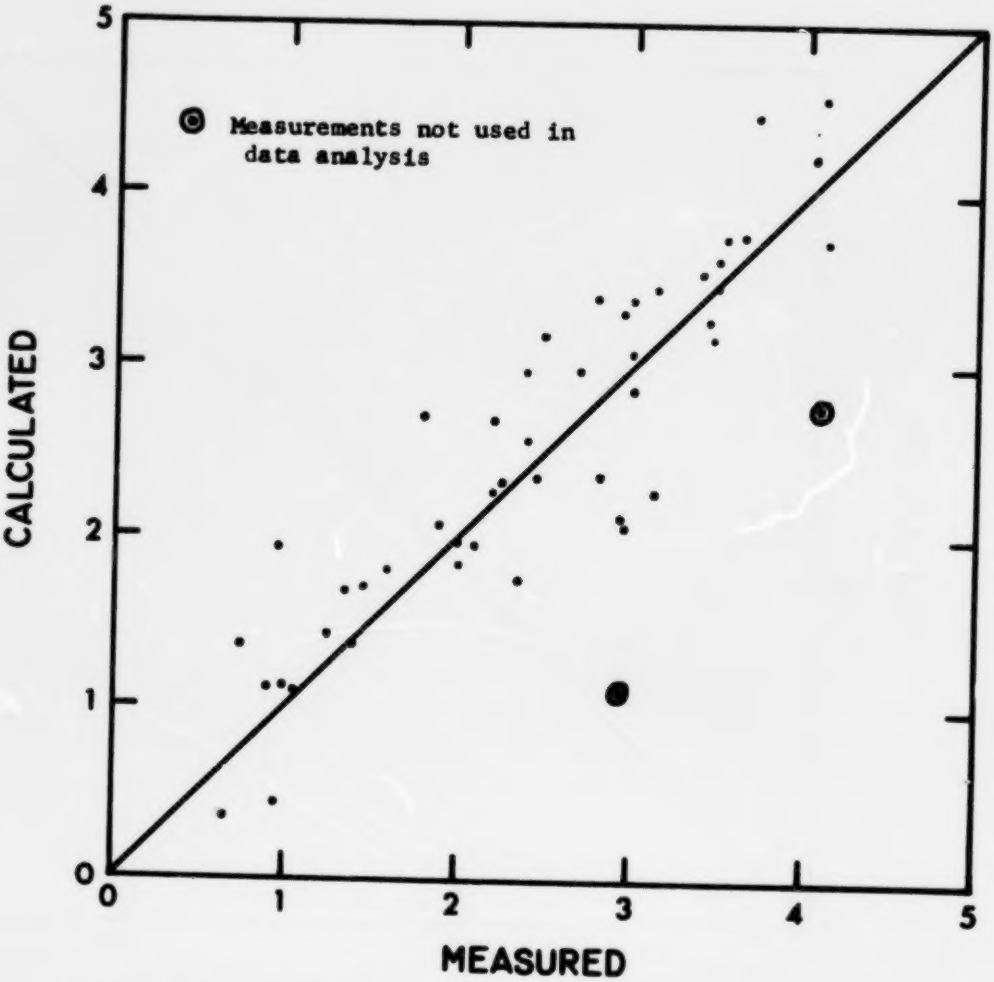


Figure 10.1 Pond 10 measured versus calculated ambient air concentrations at samplers x10^{-6} g moles/m^3

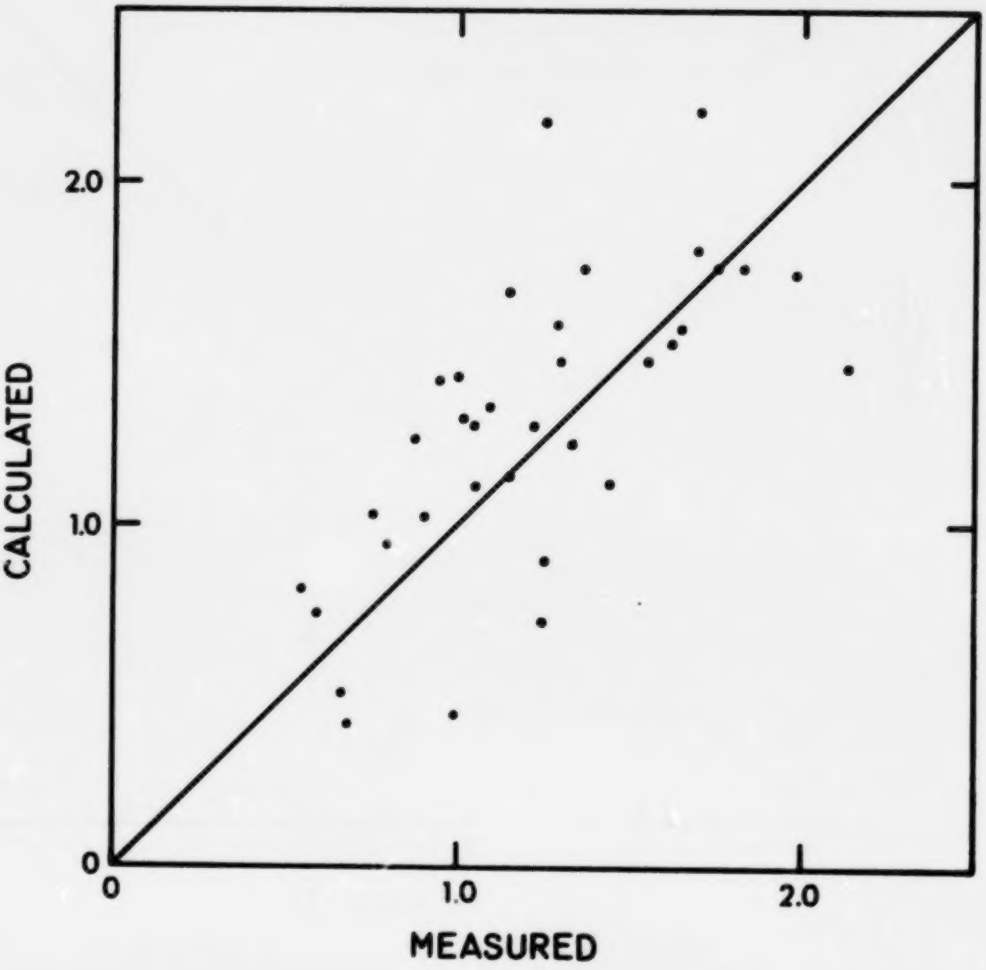


Figure 10.2 Pond 20 measured versus calculated ambient air concentrations at samplers x10^{-6} g moles/m^3

Table 10.1 Least squares regressions of calculated ambient air fluorine concentrations on measured concentrations

Pond	a^{v}	b^{v}	Number of Observations	F	R^2
	(Standard Error)				
10	.2536 (.16825)	.9122 (.06346)	50	206.58	.81145
20	.1043 (.15425)	.9888 (.12911)	37	58.649	.62626

Table 10.2 Testing the coefficients of the least squares regressions of the calculated fluorine concentration on the measured fluorine concentration with the student's t test to determine if $a^v = 0$ and $b^v = 1$

Pond	Value of t For a^v	Significant[a]	Value of t For b	Significant[a]
10	1.507	No	1.383	No
20	.67626	No	.0868	No

[a] At 95% confidence level

fluorine concentration downwind of a pond is statistically the same as the measured value.

10.2 Background Concentrations

In the Pond 10 studies six samples were taken at Station 03 when this station was upwind of the pond, that is, when the wind was blowing from the south. These runs are tabled at the end of Appendix 15.4. Three samples showed no ambient air fluorine content; three samples showed an average of 0.8×10^{-6} g moles/m^3 of fluorine not emitted from the pond. The source of this fluorine was not identified; however, it is possible that fluorine contaminated water got into the water course just southwest of the sampler. If this is the fluorine source measured by the 03 sampler, the contribution of this source to the measured fluorine concentration at sampler 01 can be approximated by the ratios of the vertical dispersion coefficients

$$\Delta C_{01} = \Delta C_{03}\left(\frac{\sigma_{z-03}}{\sigma_{z-01}}\right)$$

$$C_{03} = .8 \times 10^{-6} \text{ g moles/m}^3$$

$$\sigma_{z-01} = 44 \text{ (3 stability, .6 kilometers)}$$

$$\sigma_{z-03} = 7.7 \text{ (3 stability, .1 kilometers)}$$

$$C_{01} = .14 \times 10^{-6} \text{ g moles/m}^3 .$$

Since the measured concentrations at sampler 01 was usually over 2×10^{-6} g moles/m^3, the contribution of the source upwind of sampler 03 approaches the experimental error level.

The variation in wind and the topography of Pond 20 prevented the location of samplers upwind of the pond. However, three ambient air fluorine samples were taken under conditions that calculation shows that the pond did not contribute to the measured fluorine concentration. These samples can be used to predict the background concentration. The average measured concentration of the samples is $.36 \times 10^{-6}$ g moles of fluorine/m^3; the estimated stability classification is 5 during all three sampling periods. However, most of the measurements were made with 1 and 2 stability classifications. If the assumption is made that the fluorine measured during the three sampling periods was coming from an infinite line source 4 kilometers away, then the ratio of the measured background value when the stability class is 5 to the value when the stability class is 2 is equal to the ratio of the vertical dispersion coefficient at 4 kilometers. With the above assumption about the fluorine source, the estimated background ambient air concentration, when the air stability category is 2, is $.036 \times 10^{-6}$ g moles fluroine/meter^3. Since most measured concentrations were in the .25 to 2.0×10^{-6} g moles/m^3 range, a background concentration of this level has an insignificant effect on the study's conclusions.

10.3 Conclusions

Based on the demonstration that the measured and predicted values of ambient air fluorine concentrations downwind of two different ponds are not significantly different and that "background" or sources other than the pond did not contribute significantly to the measured values, the conclusion is reached that the pond simulation and its component parts is an accurate representation of the pond and the dispersion of fluorine downwind of the pond.

11. EMISSION ESTIMATES

11.1 This Study

In Chapter 10 it was demonstrated that the pond emission and ambient air fluorine concentration simulation could accurately predict fluorine concentrations downwind of ponds. Therefore, the calculation procedures used in the simulation can be used to produce valid pond emission estimates.

Figure 1.1 and 1.2 are the calculated emission estimates. These estimates were calculated from the equation

$$N_f = K_f(p^* - p)$$

where

$$K_f = 1.96 \times 10^3 u_{16}^{.8} \frac{\text{lb}}{\text{acre-day-mm Hg}} \qquad (33)$$

u_{16} = velocity at 16 meters in meters/sec

p^* = fluorine partial pressures from the vapor pressure curves (Figure 7.1)

p = ambient air fluorine partial pressure

= 0[9].

The solid portions of the emission estimate lines are calculated from pond water temperatures and wind speeds actually experienced in the field. Therefore, these portions, based on Chapter 10, are substantitated by field measurements.

---

[9] Typical values of (p^*-p) observed in Chapter 10 were $(700-30) \times 10^{-6}$; therefore, the approximation $p = 0$ seems reasonable

11.2 Other Studies

Cross and Ross [5] placed a floating greenhouse on a pond, drew air through it and measured the fluorine concentration in the air leaving it. From these measurements they calculated a pond emission factor of 0.16 lb/acre day. The flow patterns in their sampler are complex, so testing their results against theoretical calculations is impossible. Tatera [25] and the authors of AP 57 [1] report emission estimates based on wind tunnel studies. Tatera's wind tunnel was rectangular, and the one used in the study reported in AP-57 was semicircular[10/]. In either configuration, secondary flows perpendicular to the major flow are likely to occur [17, p. 207-209] when conditions are turbulent. These flows make direct comparison between studies difficult.

AP-57 experimented with temperatures in the range 50 to 75°F. The correlation line shows a rising trend over the entire range; however, the raw data are not presented so a re-evaluation of the trends is impossible.

Tatera plots emission rates developed from his wind tunnel work against pond water temperature in two figures reproduced here as Figure 11.1. Tatera correlated the data as straight lines. Study of

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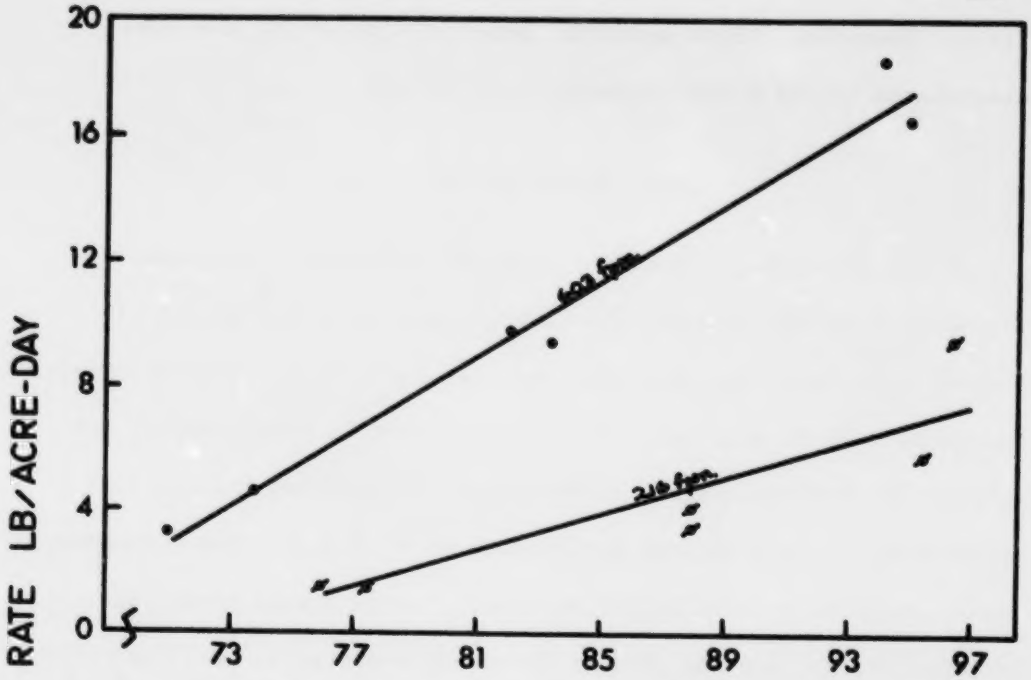
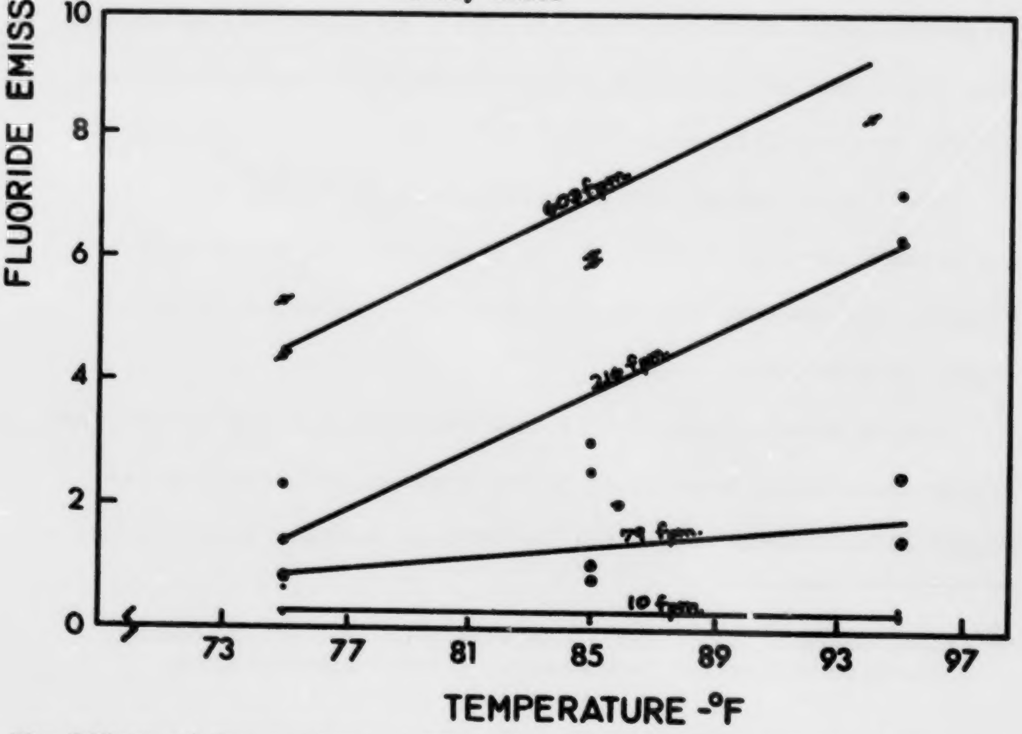
[10/] Crane, George. July, 1971. Environmental Protection Agency, Division of Applied Technology. Private communication.



The Effect of Temperature on Fluoride Emission From Gypsum Slurry Water



The Effect of Temperature on Fluoride Emission From Process Water the figures shows that the data points around 85°F consistently fall below the correlation line. This indicates that a concave upward (u shaped) curve such as predicted in this study would fit the data better. In one set of experiments the gas flow was laminar (10 ft/min). Under the laminar regime the secondary flows do not occur. In these experiments, Tatera's results showed the same trend of emission factors (E) with temperature as this study -

$E_{75°F} > E_{95°F} > E_{85°F}$.

12. FUTURE WORK

The recommendations for additional work in this section are divided into two parts:

1) Studies that are extensions of this work.
2) Studies that are off-shoots of this work.

12.1 Extensions

The study reported here has proven that ponds are fluorine emitters of considerable magnitude when compared to other sources in well-controlled wet-process acid plants. The next logical step in developing a control strategy is to answer the question - "What are the benefits and costs of controlling these fluorine emissions?" A study to develop an answer to the question is obviously multi-disciplinary; it will involve specialists drawn from the broad disciplines of engineering, biology, and meteorology. Since all disciplines are represented on campus, the university could answer the question posed above. The Engineering School, Design Center would seem to this author to be the appropriate group to co-ordinate the on-campus efforts and to seek EPA funding.

The cost-benefit study in addition to answering the primary question may identify knowledge, gaps, or technology problem areas. (For example, the study might conclude that control costs are too high or that insufficient information exists to translate ambient air fluorine concentrations into yield losses in orange groves.) These areas of potential research should be listed in order of priority along with the two areas of specific research suggested by this report (see the following paragraph) to determine the most profitable areas for further work.

Two specific areas for additional studies suggested by this report are:

1) A study to define the chemistry of the pond water system should be considered. In addition, to rationalizing the "u-shaped" vapor pressure curve, this study may yield clues to advanced control methods.
2) Additional vapor-pressure, ambient-air measurements should be considered for verification of and to add to the existing data base.

However, as suggested in the preceding paragraph, funding this work should await the completion of the benefit-cost study so that the importance to the entire control strategy of expanding the technical data base can be evaluated along with the data deficiencies brought to light by the cost-benefit study.

12.2 Offshoots

This study has developed techniques, experience and computer programs to measure and evaluate emissions from diffuse sources. At present, complex sources - parking lots - are the most important diffuse sources for which EPA had developed control strategy. This author would recommend that EPA consider funding studies which would measure complex source emissions, using the methods of this study, to expand the complex source data base.

13. NOMENCLATURE

A_{ij}	Coefficients of van Laar equation defined in Equations (56) and (57).
a_1	Activity coefficient of water in liquid phase
a_H	Activity coefficient of hydrogen ion
a_F	Activity coefficient of fluorine ion
a_{HF}	Activity coefficient of hydrogen fluoride
a'',a	Constants defined by Equations (6) and (8) respectively
a'	Empirical constant defined by Equation (26)
a^v	Empirical constant defined by Equation (42)
b	Statistical velocity exponent defined by Equation (9)
b'	Empirical constant defined by Equation (20)
b^v	Empirical constant defined by Equation (42)
$c(x,y,z,h)$	Concentrations at a sampler x meters downwind of a source, y meters from a line through the source in the direction of the wind, and z meters above the ground; source h meters above the ground
$\bar{c}(x,y,z,h)$	Time average value of $c(x,y,z,h)$
c	Molar concentration
D	Empirical constant, Equation (25)
D_{aB}	Diffusivity of B in air
D_{aw}	Diffusivity of water in air
D_{af}	Diffusivity of fluorine in air
D_{aHF}	Diffusivity of hydrogen fluoride in air
D_{aSiF_4}	Diffusivity of silicon tetrafluoride in air

D_T	Sampler tube diameter
E	Sampler efficiency
f	Friction factor
G	Excess molal free energy of solution
g_c	Gravitational constant
K	Overall gas side mass transfer coefficient for water
K_F	Overall gas side mass transfer coefficient for fluoride
K_1	Equilibrium constant defined by Equation (40)
K_a	Equilibrium constant defined by Equation (41)
K_I	Equilibrium constant defined by Equation (48)
K_0	Von Karmon's constant (0.4)
K_T	Equilibrium constant defined in Section 7.2
$\bar{k}_l$	Average liquid side mass transfer coefficient
k_y	Local gas side mass transfer coefficient
$\bar{k}_y$	Average gas side mass transfer coefficient
$\bar{k}_{aw}$	Average gas side mass transfer coefficient describing the transfer of water in air
$\bar{k}_{af}$	Average gas side mass transfer coefficient describing the movement of fluorine in air
L	Temperature lapse - air temperature measured at 16 meters minus air temperature measured at 2 meters
L_A	Adiabatic temperature lapse defined in Chapter 5
M	Slope of vapor liquid equilibrium line
M_T	Total molar flow rate of gas or vapor
m	Empirical constant defined by Equation (34)
N	Molar mass transfer rate per unit pond surface area of water from pond to atmosphere

N_F	Molar mass transfer rate per unit pond surface area of fluorine from pond to atmosphere
N_B	Molar mass transfer rate per unit pond surface area of component B from pond to atmosphere
N'	Number of time periods
n	Wind speed profile predictor exponent - empirical variable defined by Equation (35)
n'	Number of experimental observations in a data set
P	Total system pressure
P_i	Vapor pressure of i
P_F	Vapor pressure of HF
P_0	Vapor pressure of water
p	Partial pressure of water in the atmosphere above a pond
p_F	Partial pressure of fluorine in the atmosphere above a pond
p_B	Partial pressure of component B in the atmosphere above a pond
p^*	Partial pressure of water in equilibrium with pond water
p_F^*	Partial pressure of fluorine in equilibrium with pond water
p_B^*	Partial pressure of component B in equilibrium with pond water
q	Pond emission rate per unit width
q'	Number of regression coefficients in an equation
R	Gas law constant
R_i	Amount of fluorine recovered in a sampler
S	Thickness of laminar plus transition sublayers in air over pond
T	Absolute temperature
u	Wind speed or air velocity
u_1	Wind speed at edge of laminar sublayer

u_x	Wind speed at height x above ground or pond
U^*	Friction velocity, $\sqrt{\tau g_c/\rho}$
Y_1Y_2	Perpendicular distance from a line through a sensor parallel to the wind to the edge of the pond
Y^+	Dimensionless distance, $zu^*\rho/\mu$
Y_{Bi}	Mole fraction of B at the air pond interface
Y_i	Mole fraction of water at the air pond interface
Y_B	Mole fraction of B in air
Y_{BI}	Mole fraction of B at upwind end of pond
Y_{BF}	Mole fraction of B at downwind end of pond
Y_{B1}	Mole fraction of B at edge of laminar sublayer
V_T	Volumetric flow rate in sampler
w	Width of pond perpendicular to the direction of wind flow
X_1	Liquid phase mole fraction of water
X_F	Liquid phase mole fraction of fluoride ion
X_H	Liquid phase mole fraction of hydrogen ion
X_{HF}	Liquid phase mole fraction of hydrogen fluoride
X_T	Sampler tube length
x	Length of pond or plate in direction of air flow
z	Vertical distance above pond
z_1	Edge of laminar sublayer
Z	Sampler height
Z_0	Surface roughness parameter
γ	Activity coefficient
θ	Time

μ	Air viscosity
ρ	Air density
σ_z,σ_y	Vertical and horizontal dispersion coefficients
τ	Sheer stress in air at air water surface

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15. APPENDIX

15.1 Discussion of Partial Pressure Assumptions in Mass Transfer Development

In the development of the water mass transfer correlation, three assumptions concerning the water partial pressure driving force in the mass transfer equation were made:

1) the water content of the air did not vary across Lake Hefner,
2) the water content of the air did not vary with height above the ground or lake, and
3) the lake water temperature - and hence the equilibrium water partial pressure in the vapor phase (p*) - is constant across the lake.

These three assumptions are considered in the following paragraphs.

Lake water temperature measurements were measured routinely at only four points on the lake. Any assumption that these routine measurements accurately describe the lake surface temperature profile is suspect because the differences between measurement sites are constant and large. For example, in October, 1950 [17, Table 11], station 4 (Figure 4.2) recorded a higher 24 hour average temperature than station 2 on each of the 26 days with usable information; the average value of this difference was 2.0°C.

Occasionally more complete temperature profiles of the lake were constructed with a single boat-mounted thermometer [28, Table 16]. Temperature-location profiles of the lake taken over periods of time short enough to be considered instantaneous (0.5 hours) showed lake surface temperature variations on the order of 0.6°C. This temperature variation is equivalent to a saturation partial pressure variation of about .95 mm Hg at 80°F.

On a number of days (7) when the wind was blowing from station 2 across the lake to station 4, the assumption that the linear force as defined in this study

$$(p^* - p_2)$$

where

p^* = partial pressure of water in equilibrium with lake - water temperature measured at station 1

p_2 = partial pressure of water in air measured at station 2 two meters above the ground

was not significantly different than the log mean driving force defined by the equation

$$\frac{p_4 - p_2}{\ln\left(\frac{p^*-p_4}{p^*-p_2}\right)}$$

where

p_4 = partial pressure of water in air measured at station 4 two meters above the ground

was tested statistically. The null hypothesis was that the difference between the two driving forces was zero; the alternate hypothesis was that the difference between the two driving forces was not zero. The

Student's t test showed the linear driving force to be statistically greater than the log mean; the average difference was .65 mm Hg. However, as shown in a later paragraph, most of this difference may be due to a measurement error. If the wind blew equally and randomly from all directions, the only effect of the linear driving force assumption would be to increase the experimental variance. Examination of the wind records shows that the wind blows from station 2 more often; therefore, the approximation probably overestimates the water partial pressure driving force.

A sample of humidity profiles [17, p. 487] was studied to determine whether the water content of the air varied in the vertical direction both upwind and downwind of the pond. The statistics tested were various upwind and downwind combinations of the difference between the 24 hour average water content measured at 2 meters and the 24 hour average water content measured at 4.8, and 16 meters using the two-tailed Student's t test at the 95% confidence level. The results are summarized in Table 15.1

Columns 1 and 2 in the table shows that upwind of the pond the average water content of the air measured at 4 and 8 meters above the ground is significantly different than the water content measured at 2 meters. In contrast, the difference between the 16 meter and 2 meter water content is not significant. The 4 and 8 meter differences in water content can be explained in terms of a constant temperature error at the measurement limit - 0.1°C.

Downwind, the 8 and 16 meter average water contents of air are significantly different from the 2 meter downwind concentration while

Table 15.1 Vertical water distribution upwind and downwind of pond

Height	Upwind		Downwind		Downwind x Meters Upwind 2 Meters	
	Average (p at 2 m- p at z m)	Significantly Different	Average (p at 2 m- p at z m)	Significantly Different	Average (p at 2 m- p at z m)	Significantly Different
2	---	---	---	---	-1.20	Yes
4	.25	Yes	.22	No	-----	---
8	.30	Yes	.67	Yes	- .53	Yes
16	.11	No	.79	Yes	- .41	Yes

Note: p = Partial pressure of water in air in mm of Hg
Height = Height above the lake or land surface in meters

the 4 meter difference is not significant. (Columns 3 and 4 of Table 15.1 show this trend.) Because of the size of the differences, these conclusions indicate that evaporation from the lake did not affect the water content of air at 8 and 16 meters.

Finally columns 5 and 6 compare the difference between the 2 meter upwind and the 8 and 16 meter downwind water contents. In both comparisons the average difference is significant and is about -.5 mm Hg. Since it has already been shown that there was not water accumulation above 4 meters, this difference is a measure of the between-site errors. This between-site error has a significant impact on the previous discussion of the estimated error introduced by substituting the linear average water concentration for the log mean driving force; a major portion of the apparent 0.65 mm Hg difference between the two driving forces may be due to a consistent sampling bias.

Each of the three assumptions listed in the initial paragraph of this appendix strains the assumption of a linear partial pressure driving force to some extent. However, as shown above, the errors introduced by the assumptions are small and approximately random. Therefore, they add to the variance of the calculated mass transfer coefficient but they do not alter the correlation.

15.2 Analytical Procedure

15.2.1 Equipment

Orion Research Inc., Specific Ion Meter Model 407

Orion Research Inc. TISAB (94-09-09A)

Orion Research Inc. Fluoride Ion Activity Electrode Model 94-09A

Orion Research Inc. Single Junction Reference Electrode (90-01)

Orion Research Inc. Fluoride Standard (94-09-06)

Magnetic Stirrer with Teflon Bar

100 ml Polyethylene Beakers

Pipets (glass)

Volumetric Flasks (glass)

Distilled Water

15.2.2 Procedure

1) Set up meter and 2 electrodes as described in the Orion instruction manual.
2) Once a week prepare two standards by dilution of the Fluoride Standard
   a) 1×10^{-4} g moles/L F; 10 volume percent TISAB
   b) 1×10^{-5} g moles/L F; 10 volume percent TIASB.
3) Calibrate the Specific Ion Meter with the standards as described in Orion Instruction Manual for the Model 94-09 Fluoride Electrode.
4) Between each analysis rinse the electrodes with distilled water and carefully dry with facial tissues.
5) Estimate the fluoride concentration of the unknown liquid sample. Dilute a portion of the unknown to an estimated total fluoride content of 10^{-4} to 10^{-5} g moles/Liter using conventional dilution techniques. The final diluted sample must contain 10 volume percent TIASB.

6) Measure the fluoride concentration of the diluted unknown.

15.2.3 Sample Problem

A. Estimated unknown concentration: .2 g moles/L F

B. Dilution Calculation:

$$1 \text{ ml } (.2 \text{ g moles/L}) = x \text{ ml } (5 \times 10^{-5} \text{ g moles/L})$$

$$4000 \text{ ml} = x$$

C. Dilution sequence: 1 ml of the unknown diluted to 100 ml with distilled water; 2 ml of the resultant solution diluted to 100 ml with 10 ml of TISAB and distilled water (1 ml in 5000).

D. Fluoride multiplier = fluorine concentration of original sample/fluorine concentration of diluted sample

$$\frac{100}{1} \times \frac{100}{2} = 5 \times 10^{3}$$

E. Measured Concentration: 4.78×10^{-5} g moles/L

F. Actual Concentration: Measured Concentration x Fluorine Multiplier

Actual Concentration: 4.78×10^{-5} g moles/L $\times 5 \times 10^{3} =$ .239 g moles/L

15.3 Vapor-Liquid Equilibrium for the System HF-H_2O

15.3.1 Introduction

To demonstrate that the equilibrium still and operating techniques could produce thermodynamically consistent vapor-liquid equilibrium data, the system hydrogen fluoride-water ($HF-H_2O$) was studied. This appendix describes the study and results.

15.3.2 Existing Data Correlations

15.3.2.1 Correlating equations. To obtain a dependable base against which the still measurements could be tested, correlation of the published vapor-liquid equilibrium data [3,15, 21, 22, 25] for the system $HF-H_2O$ was necessary. Most studies of the $HF-H_2O$ system [3 , p. 281; 22; 25] used "dynamic" or "gas saturation" trains of various designs to establish the two phase equilibrium. However, in at least one [21], a modified Othmar or "vapor circulation" still was used. As shown in the following paragraphs the activity coefficients can be correlated with the non-ionizing solution, binary-mixture equations developed from the Gibbs-Duhem equation with little more than the usual bending of the equation's constraints.

Ignoring the ionization of water, the Gibbs-Duhem equation for the $HF-H_2O$ system can be written[1] in terms of activities as

$$\left[X_1 \frac{\partial \ln a_1}{\partial X_1} + X_{HF} \frac{\partial \ln a_{HF}}{\partial X_1} + X_H \frac{\partial \ln a_H}{\partial X_1} + X_F \frac{\partial \ln a_F}{\partial X_1}\right]_{T,P} = 0 \tag{39}$$

where

a = activity of a component in the liquid phase,

X = mole fraction,

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[1] Turner, D. National Air Pollution Control Administration, Cincinnati, Ohio, Private communication.

Subscripts 1 = water,
HF = hydrogen fluoride,
H = hydrogen ion, and
F = fluoride ion.

In solutions of only water and hydrogen fluoride

$$X_F = X_H \ . \tag{40}$$

The ionization constant (K_a) for hydrogen fluoride can be written as

$$K_a = \frac{a_H a_F}{a_{HF}} \ . \tag{41}$$

The log form of (41) can be differentiated with respect to the mole fraction of water to yield

$$\left[\frac{\partial \ln K_a}{\partial X_1} + \frac{\partial \ln a_{HF}}{\partial X_1} = \frac{\partial \ln a_F}{\partial X_1} + \frac{\partial \ln a_H}{\partial X_1}\right]_{T,P} \ . \tag{42}$$

But,

$$\left[\frac{\partial \ln K_a}{\partial X_1}\right]_{T,P} = 0 \ . \tag{43}$$

Substitution of equations (42), (43), and (40) into (39) results in

$$\left[X_1 \frac{\partial \ln a_1}{\partial X_1} + X_{HF} \frac{\partial \ln a_{HF}}{\partial X_1} + X_H \frac{\partial \ln a_{HF}}{\partial X_1} = 0\right]_{T,P} \tag{44}$$

which rearranges to

$$\left[X_1 \frac{\partial \ln a_1}{\partial X_1} + (X_{HF} + X_H) \frac{\partial X_{HF}}{\partial X_1} \frac{\partial \ln a_{HF}}{\partial X_{HF}} = 0\right]_{T,P} \ . \tag{45}$$

By definition $a_i = \nu_i X_i$,

γ_i = activity coefficient .

Therefore, Equation (46) can be rewritten as

$$[X_1(\frac{\partial \ln \gamma_i}{\partial X_1}+\frac{\partial \ln X_1}{\partial X_1}) + (X_{HF} + X_H) \frac{\partial X_{HF}}{\partial X_1}(\frac{\partial \ln \gamma_{HF}}{\partial X_{HF}} + \frac{\partial \ln X_{HF}}{\partial X_{HF}})$$

$$= 0]_{T,P} \qquad (46)$$

or since

$$X_i \frac{\partial \ln X_i}{\partial X_i} = 1$$

Equation (45) becomes

$$[X_1 \frac{\partial \ln \gamma_1}{\partial X_1} + (X_{HF} + X_H) \frac{\partial X_{HF}}{\partial X_1} \frac{\partial \ln \gamma_{HF}}{\partial X_{HF}} = - \frac{(X_{HF} + X_F)}{X_{HF}} \frac{\partial X_{HF}}{\partial X_1}$$

$$-1]_{T,P} \; . \qquad (47)$$

Ionization constants are usually reported in terms of concentration rather than activity

$$K_I = \frac{(C_H)(C_F)}{(C_{HF})} = \frac{C_T X_H^2}{X_{HF}} \qquad (48)$$

where

C = concentration, and

C_T = total concentration.

Assuming constant total concentration and differentiating Equation (48) with respect to X_1 yields

$$\left[X_{HF} \frac{\partial K_I}{\partial X_1} + K_I \frac{\partial X_{HF}}{\partial X_1} = 2X_H\, C_T \frac{\partial X_H}{\partial X_1}\right]_{T,P} . \tag{49}$$

Differentiating the identity

$$X_1 + X_{HF} + X_H + X_F = 1$$

with respect to the mole fraction of water results in

$$\left[1 + \frac{\partial X_{HF}}{\partial X_1} + 2 \frac{\partial X_H}{\partial X_1} = 0\right]_{T,P} . \tag{50}$$

Substituting Equation (49) into (50) to eliminate $\partial X_H/\partial X_1$ and the result into (48) to eliminate K_I yields

$$\left[\frac{\partial X_{HF}}{\partial X_1}\right]_{T,P}\left(\frac{X_{HF} + X_H}{X_{HF}}\right) = - 1 - \frac{X_{HF}}{X_H C_T} \left[\frac{\partial K_I}{\partial X_1}\right]_{T,P} . \tag{51}$$

Equation (51) shows that if

$$\left[\frac{\partial K_I}{\partial X_1}\right]_{T,P} = 0$$

and

$$X_{HF} + X_H \approx X_{HF}$$

Equation (47) reduces exactly the non-ionized form

$$\left[X_1 \frac{\partial \ln \gamma_1}{\partial X_1} + (X_{HF}) \frac{\partial \ln \gamma_{HF}}{\partial X_{HF}} = 0\right]_{T,P} . \tag{52}$$

The author was unable to find any data describing the ionization constant of HF in water as a function of composition. However, data [11] to evaluate the function

$$\left[\frac{\partial K_I}{\partial X_1}\right]_{T,P}$$

is available for both a weaker acid (acetic) and a stronger acid (hydrochloric).

	$\left(\frac{\partial K_I}{\partial x_1}\right)_{T,P}$
Acetic Acid (.05 M/L)	0
Hydrochloric Acid (.05)	-.11
Hydrochloric Acid (.1 M/L)	-.21 .

If the partial derivative for the $HF\text{-}H_2O$ system is within the range of values tabled above, then

$$0 < \frac{X_{HF}}{X_H C_T} \left(\frac{\partial K_I}{\partial X_1}\right)_{T,P} < -.045 \tag{53}$$

where

$X_{HF} = .10$, and

$K_I = 6.9 \times 10^{-4}$.

From the above discussion it can be seen that Equation (52) probably describes the weak acid in water system ($HF\text{-}H_2O$) satisfactorily; therefore, the Van Laar equations were used to correlate the activity coefficients.

15.3.2.2 Correlations. Activity coefficients[12/] were calculated from Equations (54) and (54a)

[12/] Reference [24] is a good short discussion of the theory and assumptions used in this section; reference [12, p. 731] is a more complete discussion

$$\gamma_F = p_F/(X_F P_F) \quad (54)$$

$$\gamma_0 = p_0/(X_0 P_0) \quad (54a)$$

where

p_i = partial pressure of i in the vapor phase,

X_i = mole fraction of i in the liquid phase,

P_i = vapor pressure of i at the temperature at which the measurement is being made, and

γ_i = liquid phase activity coefficient

Subscript

0 = H_2O, and

F = HF .

These equations assume that the behavior of the gaseous phase is ideal.

As a preliminary check of thermodynamic consistency, the Redlich and Kister test [12, p. 731] was applied to the three isotherms in the literature that covered a sufficiently wide liquid phase concentration, $X_F \geq .50$. This test is based on the equation

$$RT \int_0^1 \ln \left(\frac{\gamma_F}{\gamma_0}\right) dX_{HF} = \left[(G)_{X_{HF} = 1.0} - (G)_{X_{HF} = 0}\right] = 0 \quad (55)$$

where

G = excess molal free energy of solution,

T = absolute temperature,

X_{HF} = mole fraction hydrogen fluoride, and

R = gas law constant.

The data were tested by plotting in (γ_F/γ_0) against X_F, Figure 15.1, and observing whether the area under the curve is zero. The evidence presented in Figure 15.1 is not overwhelming but the conclusion was reached that the isotherms are probably consistent with the Redlich-Kister criteria. For each publication at each temperature level, the activity coefficients of both water and hydrogen fluoride were plotted on semi-log paper against the liquid phase HF mole fraction. The plots produced from the Brosher _et_ _al_. [3] data showed significant positive deviations from linearity below about 10 mole percent HF. This indicates that liquid was entrained into the vapor samples. Tatera worked with very dilute solutions (.5 M/L and less); therefore, plots of γ_0 could not be prepared from his data. The two suffix van Laar equations for binary solutions

$$\log_{10}\gamma_F = a_{F0}/[1 + (A_{F0}X_F/A_{0F}X_0)]^2 \tag{56}$$

$$\log_{10}\gamma_0 = A_{0F}/[1 + (A_{0F}X_0/A_{F0}X_F)]^2 \tag{57}$$

were fitted by eye to each set of activity coefficient plots and the coefficients, A_{F0} and A_{0F}, of the van Laar activity coefficient extracted.

If the partial heat of solution of i in j is constant[13/], a plot of log γ_i against reciprocal absolute temperature at a constant liquid composition is linear. Since log γ_i approaches A_{ij} as X_i

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[13/] This is a usually valid assumption made over short temperature ranges in the absence of experimental data

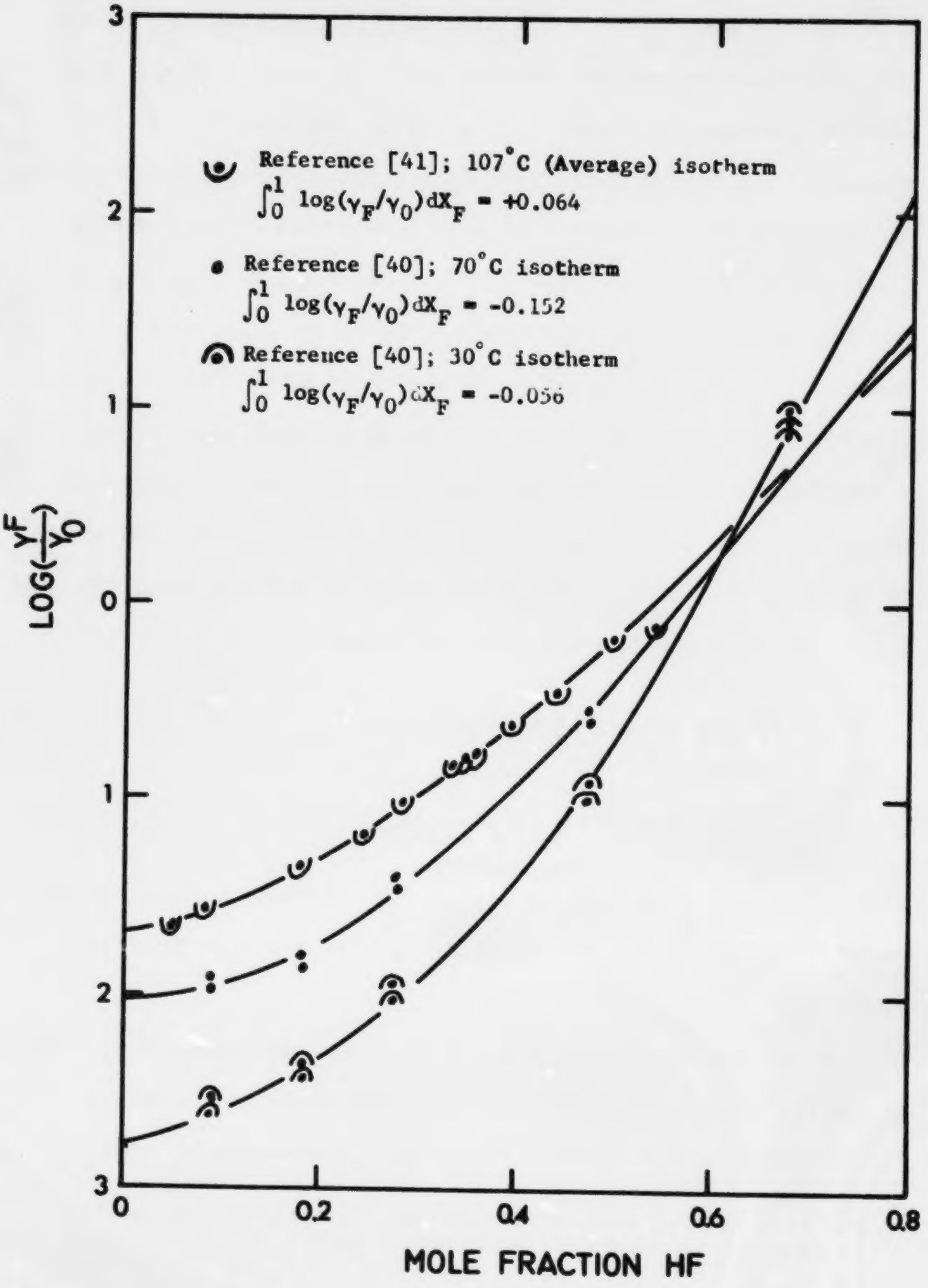

Figure 15.1 Application of Redlich-Kister Test of thermodynamic consistency to $HF-H_2O$ vapor-liquid isotherm

approaches zero, A_{ij} is similarly related to temperature. Figure 15.2 and 15.3 are plots of the van Laar equation coefficients, A_{0F} and A_{F0} , against reciprocal absolute temperature. These plots indicate reasonable consistency between the various authors. (Since other of Tatera's results are used in Section 7.2, his agreement with the others is submitted as an indication of the quality of his vapor pressure measurements.)

The individual data points shown on Figures 15.2 and 15.3 were weighted according to the number of experimental vapor-liquid equilibrium measurements on which they were based and whether the measurements could be shown to be consistent with the Redlich-Kister criteria. The weighted data were used to develop linear least squares correlations for A_{0F} and A_{F0} . Table 15.2 contains the individual experimental coefficients of the van Laar equations and the weighting factors used in developing the correlations. Table 15.3 is a statistical summary of the two correlations. In both cases F is statistically significant at the 95% confidence level.

15.3.3 Comparison of this Study's Results with HF-H_2O Correlations

The experimental measurements of the HF-H_2O system are shown in Table 15.4. Because of time limits, measurements were made at only one or two liquid compositions at each temperature. Therefore, comparisons were made of the measured average activity coefficient with the values predicted for the previously developed correlations for each temperature and liquid phase composition. Table 15.5 is the

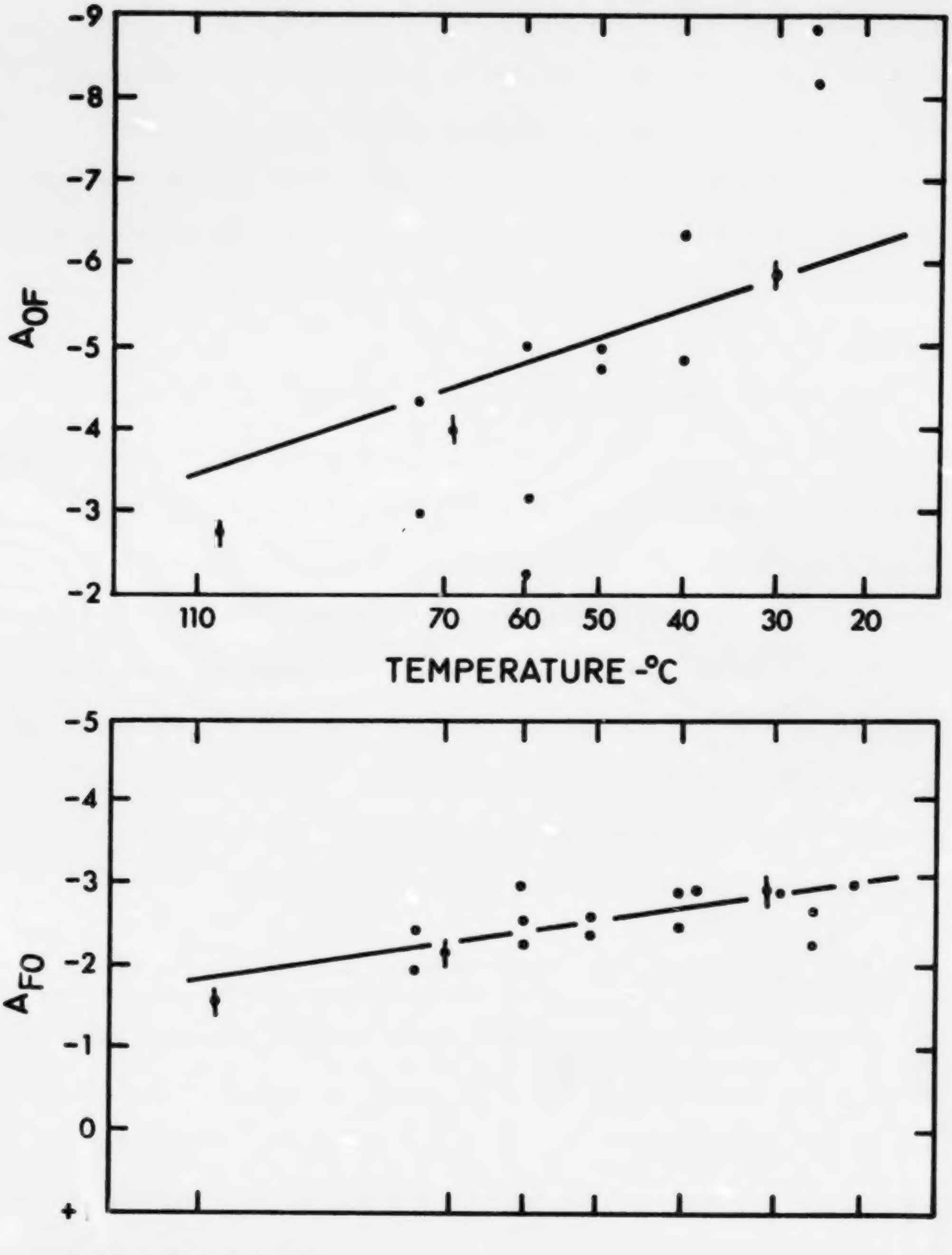

Figure 15.2 and 15.3 Van Laar equation coefficients versus reciprocal absolute temperature for the $HF-H_2O$ system

Table 15.2 Data summary; coefficients of van Laar equation calculated from individual publication isotherms and weight factor used in least squares correlation

Temperature °C	Reference	A_{FO}	A_{OF}	Number of Data Points	Redlich-Kister Consistency Test Weight Factor	Total Weight Factor
21	32	-3.000	------	13	1	13
25	38	-2.364	-8.939	3	1	3
25	39	-2.662	-8.215	10	1	10
29	32	-2.931	------	9	1	9
30	40	-2.950	-5.900	11	2	22
38	32	-2.895	------	10	1	10
40	38	-2.956	-4.883	4	1	4
40	39	-2.502	-6.435	10	1	10
50	40	-2.589	-4.760	6	1	6
50	38	-2.431	-4.967	6	1	6
60	39	-2.266	-5.059	11	1	11
60	38	-3.028	-3.221	4	1	4
60	40	-2.592	-2.350	2	1	2
70	40	-2.231	-4.052	8	2	16
75	38	-2.498	-2.985	5	1	5
75	39	-2.048	-4.436	11	1	11
107[a]	41	-1.626	-2.840	15	2	30

[a] 100-111°C actual temperature; 107°C is the assumed average

Table 15.3 System HF - H_2O statistical summary of the linear correlations[a] of the van Laar equation coefficients against reciprocal absolute temperature

	a	b $(10^{+3}\,^{\circ}K)$	Number of Data Points	F	R^2
	(Standard Error)				
A_{OF}	+5.516	-3.443	14	5.817	.3265
	(1.268)	(.4208)			
A_{FO}	+2.455	-1.582	17	51.90	.7758
	(.2005)	(.0652)			

[a] $A_{ij} = a + b\frac{1}{T}$; T = absolute temperature (°K)

result of these comparisons. The measured fluorine activity coefficients do not differ significantly from the best estimate predicted value. As the probability range in the table shows, the predicted fluorine activity coefficient values could be expected 35 to 40 times per hundred observations if they are measurements of the same thing as the correlation. Both the predicted and measured water activities are very close to 1.0 as thermodynamic theory demands for the solvent containing only a very small amount of solute. Calculation of an expected range of values for the water activity coefficient from a statistical analysis of the van Laar equation has little meaning. The van Laar equation constrains the prediction range to values less than or equal to 1. With normal experimental variation around 1, statistical theory expects some observations greater than 1.0.

Based on the agreement between the measurements made on the $HF-H_2O$ system in connection with this report and the rest of the literature, the vapor-equilibrium still designed for this study is capable of producing accurate equilibrium measurements.

Table 15.4 Data summary for the H_2O-HF system

Temp. °F	Total Pressure (mm Hg)	Mole Fraction HF Liquid Phase	Mole Fraction HF Vapor Phase	Liquid Phase Activity Coefficients HF (x 10^{-3})	Liquid Phase Activity Coefficients H_2O
68	17.3	.0297	.00430	3.250	1.013[a]
68.5	17.4	.0304	.00278	2.053	1.005
68	17.4	.0324	.00260	1.813	1.025
67	15.4	.0157	.00127	1.650	.9251
67	15.4	.0159	.00128	1.642	.9253
68.8	16.9	.0161	.00128	1.725	.9530
69	17.8	.0164	.00119	1.635	1.004
80	25.8	.0311	.00243	2.100	1.010
80	25.4	.0311	.00242	2.070	.9944
79.5	24.8	.0163	.00130	2.069	.9790
81.5	22.7	.0164	.00137	1.975	.8380[a]
79.5	25.7	.0164	.00108	1.782	1.011
90	35.7	.0166	.000866	1.648	1.016
90	35.7	.0167	.00100	1.892	1.016
88.6	34.1	.0160	.00119	2.306	1.003
88.0	33.7	.0160	.00101	1.952	1.010
87.9	33.6	.0161	.00116	2.201	1.012
90.5	34.9	.0168	.00206	3.787	.9653[a]
90.2	34.9	.0169	.00160	2.950	.9710
98.9	47.6	.0162	.00130	2.856	1.015
98.7	47.4	.0163	.000881	1.971	1.017
99.0	48.4	.0163	.000983	2.229	1.038
99.5	48.6	.0165	.00100	2.232	1.012
99.5	48.5	.0166	.00216	4.904	1.017[a]

[a] Observation not used in calculating averages shown in Table 15.5

Table 15.5 Comparison of predicted and measured activity coefficients for the HF-H_2O system

Mole Fraction Hydrogen Fluorine in Liquid Phase	Average System Temp. °F	Number of Experimental Observations	Activity Coefficient of H_2O		Activity Coefficient of HF			
						Predicted from van Laar Equation		
							40% of the time an experimental observation would be expected to be	
			Experimental Values	Predicted From van Laar Equation	Experimental Values	Best Est.	Greater Than[a]	Less Than[a]
.031	68.2	2	1.01	.997	$1.933\text{x}10^{-3}$[b]	$1.128\text{x}10^{-3}$	$.7952\text{x}10^{-3}$	$1.840\text{x}10^{-3}$
.016	67.9	4	.952	.999	$1.663\text{x}10^{-3}$	1.100	.7203	1.680
.031	80.0	2	1.00	.997	2.085	1.590	1.088	2.397
.016	79.8	2	.995	.999	1.942	1.444	.8457	2.205
.016	89.3	6	1.00	.997	2.159	1.788	1.171	2.795
.016	99.0	4	1.02	.998	2.322	2.212	1.409	3.289

[a] $(A_{FO})_{.40} = A_{FO(\text{Best Estimate})} \pm t_{.40(N=172)}\left[(\Sigma uA_{FO}^2 - \frac{(\Sigma uA_{FO})^2}{N} - \frac{b\,\Sigma\, uA_{FO}(\frac{1}{T}) - \frac{\bar{T}}{T}uA_{FO}}{N-2})(1 + \frac{1}{N} + (\frac{\bar{T}}{T} - \frac{\bar{T}}{T})^2)\right]^{\frac{1}{2}}$

$$(\gamma_F)_{.40} \simeq \frac{(A_{FO})_{.40}}{(1 + [(A_{FO})_{.5}(XF)]/[A_{OF})_{.5}X_0])^2}$$

[b] This value would be expected about 35% of the time

15.4 Usable Ambient Air Fluorine Concentration Measurements

15.4.1 Pond 10 Downwind

```
        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10    SAMPLER NUMBER 01

DATE  6/13/73    START TIME  1:00 P.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  4    WIND VEL. PROFILE EXP.  0.2100
SKY CONDITION 80% cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS    6.33 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   5.0 M/SEC
AIR TEMPERATURE   81.0F DRY BULB   76.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1                88.0              382.0E-06
   2                89.4              389.0E-06
   3                91.4              398.0E-06
   4                93.8              447.0E-06
   5                96.7              520.0E-06
   6               100.5              680.0E-06
   7               102.7              815.0E-06
   8                87.5              381.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.49500E-06  GRAM_MOLE_F
                   ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.61432E-06  GRAM_MOLE_F
                   ACTUAL CUBIC METER
```

```
          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 1C   SAMPLER NUMBER 01

DATE  6/13/73   START TIME  2:10 P.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.2180
SKY CONDITION 80% cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS    2.17 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   4.4 M/SEC
AIR TEMPERATURE    82.0F DRY BULB   78.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1                88.0               382.0E-06
   2                89.4               389.0E-06
   3                91.4               398.0E-06
   4                93.8               447.0E-06
   5                96.7               520.0E-06
   6               100.5               680.0E-06
   7               102.7               815.0E-06
   8                87.5               381.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.79400E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.37233E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
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```
        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 10   SAMPLER NUMBER 02

DATE  6/13/73   START TIME  3:30 P.M.
SAMPLING LENGTH 46.0 MIN.


AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.2090
SKY CONDITION  80% cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   -4.39 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   5.0 M/SEC
AIR TEMPERATURE   84.0F DRY BULB   79.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1               88.0              382.0E-06
   2               89.4              389.0E-06
   3               91.4              398.0E-06
   4               93.8              447.0E-06
   5               96.7              520.0E-06
   6              100.5              680.0E-06
   7              102.7              815.0E-06
   8               87.5              381.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.36400E- 06 GRAM_MOLE_F
                   ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.74787E-06 GRAM_MOLE_F
                   ACTUAL CUBIC METER
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```
           RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 10    SAMPLER NUMBER 01

DATE   6/13/73    START TIME  3:33 P.M.
SAMPLING LENGTH 45.0 MIN.


AIR STABILITY CATEGORY  4    WIND VEL. PROFILE EXP.  0.2090
SKY CONDITION    80% cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS    -4.78 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS    5.0 M/SEC
AIR TEMPERATURE    84.0F DRY BULB    79.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT       TEMPERATURE F.DEG      VAPOR PRESSURE MM HG
   1                 88.0                 382.0E-06
   2                 89.4                 389.0E-06
   3                 91.4                 398.0E-06
   4                 93.8                 447.0E-06
   5                 96.7                 520.0E-06
   6                100.5                 680.0E-06
   7                102.7                 815.0E-06
   8                 87.5                 381.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     4.09100E-06 GRAM_MOLE_F
                 ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     2.74870E-06 GRAM_MOLE_F
                 ACTUAL CUBIC METER
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              RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
     DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

     POND LOCATION CODE 10    SAMPLER NUMBER 01

     DATE   6/16/73    START TIME  8:54 A.M.
     SAMPLING LENGTH 60.0 MIN.


     AIR STABILITY CATEGORY  3-4  WIND VEL. PROFILE EXP.  0.2110
     SKY CONDITION High overcast

     TIME AVERAGE WIND DIRECTION AT 3.05 METERS   38.83 DEGREES
     TIME AVERAGE WIND SPEED AT 3.05 METERS   4.4 M/SEC
     AIR TEMPERATURE   76.0F DRY BULB   71.0F WET BULB


     POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

     SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
        1                88.3              387.0E-06
        2                89.3              389.0E-06
        3                91.1              405.0E-06
        4                93.8              445.0E-06
        5                97.4              545.0E-06
        6               101.9              710.0E-06
        7               104.7              915.0E-06
        8                87.0              384.0E-06

     MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
          3.00400E-06 GRAM_MOLE_F
                      ACTUAL CUBIC METER

     CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
          2.8487 E-06 GRAM_MOLE_F
                      ACTUAL CUBIC METER
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         RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 1C    SAMPLER NUMBER 02

DATE  6/16/73    START TIME  9:42 A.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  4    WIND VEL. PROFILE EXP.  0.1940
SKY CONDITION  High overcast with sun casting shadows

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   28.83 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   5.2 M/SEC
AIR TEMPERATURE   83.0F DRY BULB   73.5F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               89.8              391.0E-06
   2               91.0              403.0E-06
   3               92.7              429.0E-06
   4               95.8              495.0E-06
   5               99.5              630.0E-06
   6              104.0              815.0E-06
   7              106.7              116.0E-05
   8               88.6              387.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.24400E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.33492E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
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          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 10   SAMPLER NUMBER 02

DATE  6/16/73   START TIME  2:36 P.M.
SAMPLING LENGTH 55.0 MIN.


AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.1960
SKY CONDITION  High overcast

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   15.73 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   5.9 M/SEC
AIR TEMPERATURE   82.5F DRY BULB   73.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG      VAPOR PRESSURE MM HG
   1                91.0              403.0E-06
   2                92.4              420.0E-06
   3                94.3              458.0E-06
   4                97.2              535.0E-06
   5               101.0              710.0E-06
   6               105.6              106.0E-05
   7               108.7              140.0E-05
   8                90.0              392.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     2.99600E-06 GRAM_MOLE_F
                 ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     3.04420E-06 GRAM_MOLE_F
                 ACTUAL CUBIC METER
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        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 02

DATE  6/16/73   START TIME  3:42 P.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.2140
SKY CONDITION  High overcast

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   14.66 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   4.7 M/SEC
AIR TEMPERATURE   82.0F DRY BULB   73.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1               91.0              403.0E-06
   2               92.4              420.0E-06
   3               94.3              458.0E-06
   4               97.2              535.0E-06
   5              101.1              710.0E-06
   6              105.6              106.0E-05
   7              108.7              140.0E-05
   8               90.0              392.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.95800E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.29200E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
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         RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 1C   SAMPLER NUMBER 02

DATE  6/16/73   START TIME  4:48 P.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.1910
SKY CONDITION  High overcast

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   15.50 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   6.3 M/SEC
AIR TEMPERATURE   82.0F DRY BULB   74.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               91.0                 403.0E-06
   2               92.4                 420.0E-06
   3               94.3                 458.0E-06
   4               97.2                 535.0E-06
   5              101.1                 710.0E-06
   6              105.6                 106.0E-05
   7              108.7                 140.0E-05
   8               90.0                 392.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.69300E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.96684E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
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          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
 DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

 POND LOCATION CODE 10   SAMPLER NUMBER 01

 DATE  6/20/73   START TIME  4:21 P.M.
 SAMPLING LENGTH 60.0 MIN.


 AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.2530
 SKY CONDITION  Rain just over; cloud cover 100 to 50%

 TIME AVERAGE WIND DIRECTION AT 3.05 METERS   75.99 DEGREES
 TIME AVERAGE WIND SPEED AT 3.05 METERS   1.7 M/SEC
 AIR TEMPERATURE   82.0F DRY BULB   77.0F WET BULB


 POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

 SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
    1               92.6               423.0E-06
    2               94.2               450.0E-06
    3               96.6               517.0E-06
    4               99.5               630.0E-06
    5              102.7               815.0E-06
    6              106.5               115.0E-05
    7              108.8               141.0E-05
    8               92.0               417.0E-06

 MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       3.44800E-06 GRAM_MOLE_F
                   ACTUAL CUBIC METER

 CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       3.47922E-06 GRAM_MOLE_F
                   ACTUAL CUBIC METER
          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 10   SAMPLER NUMBER 01

DATE  6/21/73   START TIME  9:07 A.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.2260
SKY CONDITION   80 to 100% overcast

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   24.66 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   3.4 M/SEC
AIR TEMPERATURE   84.0F DRY BULB   78.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT     TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1              90.3                397.0E-06
   2              91.4                408.0E-06
   3              92.9                430.0E-06
   4              94.6                462.0E-06
   5              96.7                520.0E-06
   6              99.0                610.0E-06
   7             100.4                673.0E-06
   8              89.7                390.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.745000E-06 GRAM_MOLE_F
                   ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.64286E-06 GRAM_MOLE_F
                   ACTUAL CUBIC METER
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        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 10   SAMPLER NUMBER 02

DATE  6/21/73   START TIME  9:20 A.M.
SAMPLING LENGTH 62.0 MIN.


AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.2240
SKY CONDITION  50 to 100% overcast

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   19.61 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   3.4 M/SEC
AIR TEMPERATURE   84.0F DRY BULB   78.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1              90.3               397.0E-06
   2              91.4               408.0E-06
   3              92.9               430.0E-06
   4              94.6               462.0E-06
   5              96.7               520.0E-06
   6              99.0               610.0E-06
   7             100.4               673.0E-06
   8              89.4               390.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.00800E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.48232E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 02

DATE  6/21/73   START TIME  10:31 A.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.2310
SKY CONDITION Low overcast 20 minute shower just over

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   37.16 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   3.1 M/SEC
AIR TEMPERATURE   90.0F DRY BULB  UNK. F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1              90.3               397.0E-06
   2              91.4               408.0E-06
   3              92.9               430.0E-06
   4              94.6               462.0E-06
   5              96.7               520.0E-06
   6              99.0               610.0E-06
   7             100.4               673.0E-06
   8              89.4               390.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.46700E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.36260E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 01

DATE  6/21/73   START TIME  10:20 A.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.2320
SKY CONDITION  Low overcast -- 20 minute shower

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   41.33 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   3.1 M/SEC
AIR TEMPERATURE   80.0F DRY BULB  UNK.  F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT     TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1              90.3               397.0E-06
   2              91.4               408.0E-06
   3              92.9               430.0E-06
   4              94.6               462.0E-06
   5              96.7               520.0E-06
   6              99.0               610.0E-06
   7             100.4               673.0E-06
   8              89.7               390.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     4.44100E-06 GRAM_MOLE_F
                 ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     3.70909E-06 GRAM_MOLE_F
                 ACTUAL CUBIC METER
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              RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 01

DATE  6/21/73   START TIME  11:51 A.M.
SAMPLING LENGTH 44.0 MIN.


AIR STABILITY CATEGORY  3-4 WIND VEL. PROFILE EXP.  0.2290
SKY CONDITION Some sun but mostly overcast

TIME AVERAGE WIND DIRECTION AT 3.05 METERS  -15.41 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   3.0 M/SEC
AIR TEMPERATURE   80.0F DRY BULB  UNK. F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT     TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1              90.3               397.0E-06
   2              91.4               408.0E-06
   3              92.9               430.0E-06
   4              94.6               462.0E-06
   5              96.7               520.0E-06
   6              99.0               610.0E-06
   7             100.4               673.0E-06
   8              89.7               390.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.41400E-06 GRAM_MOLE_E
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.5516  E-06 GRAM_MOLE_E
                  ACTUAL CUBIC METER
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          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 02

DATE  6/21/73   START TIME  12:10 P.M.
SAMPLING LENGTH 70.0 MIN.



AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.2400
SKY CONDITION  overcast -- Rain shower after 1:10 p.m.

TIME AVERAGE WIND DIRECTION AT 3.05 METERS    2.29 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.5 M/SEC
AIR TEMPERATURE   77.0F DRY BULB   75.5F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1               89.5              390.0E-06
   2               90.9              401.0E-06
   3               92.6              415.0E-06
   4               94.8              470.0E-06
   5               97.4              540.0E-06
   6              100.5              680.0E-06
   7              102.3              785.0E-06
   8               89.0              388.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      9.43000E-07 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.91792E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
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        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 10    SAMPLER NUMBER 01

DATE  6/21/73    START TIME  2:06 A.M.
SAMPLING LENGTH 65.0 MIN.


AIR STABILITY CATEGORY  3   WIND VEL. PROFILE EXP.  0.2520
SKY CONDITION  Rain shower before 2:00 p.m.; 100 to 90% overcast

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   46.84 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.8 M/SEC
AIR TEMPERATURE   79.0F DRY BULB   77.5F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT     TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1              89.5               390.0E-06
   2              90.9               401.0E-06
   3              92.6               415.0E-06
   4              94.8               470.0E-06
   5              97.4               540.0E-06
   6             100.5               680.0E-06
   7             102.3               785.0E-06
   8              89.0               388.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.415000E-06 GRAM_MOLE_F
                   ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.965746E-06 GRAM_MOLE_F
                   ACTUAL CUBIC METER
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          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
 DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

 POND LOCATION CODE 1C   SAMPLER NUMBER 02

 DATE  6/21/73   START TIME  2:55 P.M.
 SAMPLING LENGTH 60.0 MIN.


 AIR STABILITY CATEGORY  3   WIND VEL. PROFILE EXP.  0.2490
 SKY CONDITION  90% Overcast

 TIME AVERAGE WIND DIRECTION AT 3.05 METERS   45.49 DEGREES
 TIME AVERAGE WIND SPEED AT 3.05 METERS   2.0 M/SEC
 AIR TEMPERATURE   79.0F DRY BULB   76.5F WET BULB


 POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

 SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
    1               89.5               390.0E-06
    2               90.9               401.0E-06
    3               92.6               415.0E-06
    4               94.8               470.0E-06
    5               97.4               540.0E-06
    6              100.5               680.0E-06
    7              102.3               785.0E-06
    8               89.0               388.0E-06

 MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       1.72700E-06 GRAM_MOLE_F
                   ACTUAL CUBIC METER

 CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       1.48083E-06 GRAM_MOLE_F
                   ACTUAL CUBIC METER
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        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 10   SAMPLER NUMBER 01

DATE  6/21/73   START TIME  3:20 P.M.
SAMPLING LENGTH 10.0 MIN.


AIR STABILITY CATEGORY  3   WIND VEL. PROFILE EXP.  0.2470
SKY CONDITION   90% Overcast

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   18.00 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.8 M/SEC
AIR TEMPERATURE   79.0F DRY BULB   76.5F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT     TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1              89.5               390.0E-06
   2              90.0               401.0E-06
   3              92.6               415.0E-06
   4              94.8               470.0E-06
   5              97.4               540.0E-06
   6             100.5               680.0E-06
   7             102.3               785.0E-06
   8              89.0               388.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.49000E-06 GRAM_MOLE_E
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.17498E-06 GRAM_MOLE_E
                  ACTUAL CUBIC METER
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         RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 1C   SAMPLER NUMBER 02

DATE  6/21/73   START TIME  4:06 P.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  3   WIND VEL. PROFILE EXP.  0.2330
SKY CONDITION  90% Overcast

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   50.49 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.9 M/SEC
AIR TEMPERATURE   81.0F DRY BULB   79.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               89.5               390.0E-06
   2               90.9               401.0E-06
   3               92.6               415.0E-06
   4               94.8               470.0E-06
   5               97.4               540.0E-06
   6              100.5               680.0E-06
   7              102.3               785.0E-06
   8               89.0               388.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.26600E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.39370E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
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        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 10   SAMPLER NUMBER 01

DATE  6/21/73   START TIME  4:28 P.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.2280
SKY CONDITION   95% Overcast

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   45.49 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   3.2 M/SEC
AIR TEMPERATURE   81.0F DRY BULB   79.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1              89.5               390.0E-06
   2              90.0               401.0E-06
   3              92.6               415.0E-06
   4              94.8               470.0E-06
   5              97.4               540.0E-06
   6             100.5               680.0E-06
   7             102.3               785.0E-06
   8              89.0               338.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.54400E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.76202E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 02

DATE  6/21/73   START TIME  5:16 P.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  3   WIND VEL. PROFILE EXP.  0.2300
SKY CONDITION    95% Overcast

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   51.33 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   3.0 M/SEC
AIR TEMPERATURE   81.5F DRY BULB   79.5F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT     TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               89.5             390.0E-06
   2               90.9             401.0E-06
   3               92.6             415.0E-06
   4               94.8             470.0E-06
   5               97.4             540.0E-06
   6              100.5             680.0E-06
   7              102.3             785.0E-06
   8               89.0             388.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.63900E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.35025E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 10    SAMPLER NUMBER 01

DATE  6/21/73    START TIME  5:38 P.M.
SAMPLING LENGTH 10.0 MIN.


AIR STABILITY CATEGORY  4    WIND VEL. PROFILE EXP.  0.2210
SKY CONDITION    95% Overcast

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   42.99 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   4.5 M/SEC
AIR TEMPERATURE    81.5F DRY BULB   79.5F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1                89.5                390.0E-06
   2                90.0                401.0E-06
   3                92.6                415.0E-06
   4                94.8                470.0E-06
   5                97.4                540.0E-06
   6               100.5                680.0E-06
   7               102.3                785.0E-06
   8                89.0                388.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.261000E-06 GRAM_MOLE_F
                   ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.440000E-06 GRAM_MOLE_F
                   ACTUAL CUBIC METER
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          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 10   SAMPLER NUMBER 01

DATE  6/22/73   START TIME  9:50 A.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  3 -4 WIND VEL. PROFILE EXP.  0.2050
SKY CONDITION  30 to 40% cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS    8.00 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   4.5 M/SEC
AIR TEMPERATURE   82.5F DRY BULB   78.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1                91.6            410.0E-06
   2                93.0            431.0E-06
   3                94.9            470.0E-06
   4                97.2            535.0E-06
   5                99.9            650.0E-06
   6               102.9            830.0E-06
   7               104.8            980.0E-06
   8                90.8            400.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.48800E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.13824 E-06 GRAM_MOLE_F
                   ACTUAL CUBIC METER
          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 1C   SAMPLER NUMBER 02

DATE  6/22/73   START TIME  10:12 A.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  3-4  WIND VEL. PROFILE EXP.  0.2040
SKY CONDITION  40% cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS    4.67 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   4.6 M/SEC
AIR TEMPERATURE   82.5F DRY BULB   78.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT       TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1                91.6             410.0E-06
   2                93.0             431.0E-06
   3                94.9             470.0E-06
   4                97.2             535.0E-06
   5                99.9             650.0E-06
   6               102.9             830.0E-06
   7               104.8             980.0E-06
   8                90.8             400.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     1.91400E-06 GRAM_MOLE_F
                 ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     2.0545   E-06 GRAM_MOLE_F
                 ACTUAL CUBIC METER
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        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 02

DATE  6/22/73   START TIME  11:22 A.M.
SAMPLING LENGTH 62.0 MIN.



AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.2020
SKY CONDITION 50 to 80% low cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   11.22 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   4.7 M/SEC
AIR TEMPERATURE   86.0F DRY BULB   78.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1              91.6              390.0E-06
   2              93.0              401.0E-06
   3              94.9              415.0E-06
   4              97.2              470.0E-06
   5              99.9              540.0E-06
   6             102.9              680.0E-06
   7             104.8              785.0E-06
   8              90.8              388.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.80200E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.36543E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
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            RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 1C   SAMPLER NUMBER 02

DATE  6/22/73   START TIME  12:32 P.M.
SAMPLING LENGTH 33.0 MIN.


AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.1930
SKY CONDITION 80 to 90% low cloud cover; rain after 1:07 p.m.

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   42.09 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   5.5 M/SEC
AIR TEMPERATURE   84.0F DRY BULB   79.5F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               91.6               410.0E-06
   2               93.0               431.0E-06
   3               94.7               470.0E-06
   4               97.2               535.0E-06
   5               99.9               650.0E-06
   6              102.9               830.0E-06
   7              104.8               980.0E-06
   8               90.8               400.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.66900E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.21947E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
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       RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 10    SAMPLER NUMBER 02

DATE  6/22/73   START TIME  2:28 P.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.2100
SKY CONDITION 100% low overcast; rain before run; trace for 5 min.
                                         during run
TIME AVERAGE WIND DIRECTION AT 3.05 METERS   28.00 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   4.4 M/SEC
AIR TEMPERATURE   80.0F DRY BULB   77.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT       TEMPERATURE F.DEG      VAPOR PRESSURE MM HG
   1                94.1               450.0E-06
   2                95.5               484.0E-06
   3                97.4               545.0E-06
   4                99.7               640.0E-06
   5               102.4               795.0E-06
   6               105.4               103.0E-05
   7               107.3               123.0E-05
   8                93.3               438.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.07200E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.98103E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
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          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 01

DATE  6/22/73   START TIME  2:37 P.M.
SAMPLING LENGTH 65.0 MIN.



AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.2070
SKY CONDITION  100% low overcast; rain before run; trace for 5 min.
                                               during run
TIME AVERAGE WIND DIRECTION AT 3.05 METERS   26.84 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   4.6 M/SEC
AIR TEMPERATURE    80.0F DRY BULB   77.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1              94.1              450.0E-06
   2              95.5              484.0E-06
   3              97.4              545.0E-06
   4              99.7              640.0E-06
   5             102.4              795.0E-06
   6             105.4              103.0E-05
   7             107.3              123.0E-05
   8              93.3              438.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     4.09300E-06 GRAM_MOLE_E
                 ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     4.58660E-06 GRAM_MOLE_E
                 ACTUAL CUBIC METER
          RUN SUMMARY - AMBIENT AIR FLLORIDE CCNCENTRATICN
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 10   SAMPLER NUMBER 02

DATE  6/22/73   START TIME  3:37 P.M.
SAMPLING LENGTH 60.C MIN.


AIR STABILITY CATEGORY  3-4 WIND VEL. PROFILE EXP.  0.2090
SKY CONDITION 90% overcast, Mixed mid and low cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   27.16 DEGREES
TIME AVERAGE WINC SPEED AT 3.05 METERS   4.5 M/SEC
AIR TEMPERATURE   81.5F DRY BULB   77.5F WET BULB


POND TEMPERATURE - FLUCRIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG    VAPCR PRESSURE MM HG
   1               93.3              438.0E-06
   2               95.0              472.0E-06
   3               97.0              530.0E-06
   4              10C.3              670.0E-06
   5              103.8              9C0.0E-06
   6              107.9              130.0E-05
   7              11C.3              162.0E-05
   8               92.4              420.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.80300E-06 GRAM_MCLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CCNCENTRATION
      2.6807   E-06 GRAM_MCLE_F
                  ACTUAL CUBIC METER
          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 01

DATE  6/22/73   START TIME  3:51 P.M.
SAMPLING LENGTH 59.0 MIN.



AIR STABILITY CATEGORY  3-4  WIND VEL. PROFILE EXP.  0.2090
SKY CONDITION  90% overcast mixed mid and low cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   28.76 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   4.4 M/SEC
AIR TEMPERATURE   81.5F DRY BULB   77.5F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1                93.3              438.0E-06
   2                95.0              472.0E-06
   3                97.0              530.0E-06
   4               100.3              670.0E-06
   5               103.8              900.0E-06
   6               107.9              130.0E-05
   7               110.3              162.0E-05
   8                92.4              420.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      4.06500E-06 GRAM_MOLE_E
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     4.2104   E-06 GRAM_MOLE_E
                  ACTUAL CUBIC METER
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        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 02

DATE  6/22/73   START TIME  4:40 P.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  3   WIND VEL. PROFILE EXP.  0.2200
SKY CONDITION 90% overcast

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   41.33 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   3.7 M/SEC
AIR TEMPERATURE   82.0F DRY BULB   77.5F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1              93.3               438.0E-06
   2              95.0               472.0E-06
   3              97.0               530.0E-06
   4             100.3               670.0E-06
   5             103.8               900.0E-06
   6             107.9               130.0E-05
   7             110.3               162.0E-05
   8              92.4               420.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.58600E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.81145E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 01

DATE  6/22/73   START TIME  4:58 P.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  3   WIND VEL. PROFILE EXP.  0.2270
SKY CONDITION    90% overcast

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   38.83 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   3.3 M/SEC
AIR TEMPERATURE   82.0F DRY BULB   77.5F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               93.3               438.0E-06
   2               95.0               472.0E-06
   3               97.0               530.0E-06
   4              100.3               670.0E-06
   5              103.8               900.0E-06
   6              107.9               130.0E-05
   7              110.3               162.0E-05
   8               92.4               420.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.02100E-06 GRAM-MOLE-F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.35048E-06 GRAM-MOLE-F
                  ACTUAL CUBIC METER
        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10    SAMPLER NUMBER 01

DATE  6/27/73   START TIME  9:35 A.M.
SAMPLING LENGTH 61.0 MIN.


AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.2580
SKY CONDITION    100% low cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS -115.43 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.8 M/SEC
AIR TEMPERATURE   78.0F DRY BULB   76.5F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               89.4               383.0E-06
   2               90.8               387.0E-06
   3               93.0               400.0E-06
   4               95.6               425.0E-06
   5               98.9               474.0E-06
   6              102.8               565.0E-06
   7              105.2               645.0E-06
   8               88.6               381.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      9.42000E-07 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      4.28777E-07 GRAM_MOLE_F
                  ACTUAL CUBIC METER
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          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
 DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

 POND LOCATION CODE 10   SAMPLER NUMBER 01

 DATE  6/27/73   START TIME  11:39 A.M.
 SAMPLING LENGTH 60.0 MIN.


 AIR STABILITY CATEGORY  3   WIND VEL. PROFILE EXP.  0.2660
 SKY CONDITION  80% overcast

 TIME AVERAGE WIND DIRECTION AT 3.05 METERS -142.82 DEGREES
 TIME AVERAGE WIND SPEED AT 3.05 METERS   1.4 M/SEC
 AIR TEMPERATURE   81.0F DRY BULB   78.0F WET BULB


 POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

 SEGMENT      TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
    1               92.6              389.0E-06
    2               94.2              401.0E-06
    3               96.4              431.0E-06
    4               98.9              485.0E-06
    5              102.0              600.0E-06
    6              105.4              825.0E-06
    7              107.3              101.0E-05
    8               91.8              385.0E-06

 MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       6.36000E-07 GRAM_MOLE_F
                   ACTUAL CUBIC METER

 CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       3.31651E-07 GRAM_MOLE_F
                   ACTUAL CUBIC METER
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        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10    SAMPLER NUMBER 01

DATE 6/28/73     START TIME 8:38 A.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  2-3  WIND VEL. PROFILE EXP.  0.2350
SKY CONDITION  clear, sunny

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   20.50 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.8 M/SEC
AIR TEMPERATURE    79.5F DRY BULB   76.5F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               80.1               408.0E-06
   2               81.2               400.0E-06
   3               82.7               387.0E-06
   4               84.7               381.0E-06
   5               87.2               382.0E-06
   6               90.3               397.0E-06
   7               92.5               421.0E-06
   8               79.6               411.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.02600E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.9730  E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
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          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 1C    SAMPLER NUMBER 02

DATE 6/28/73      START TIME 9:04 A.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  2-3 WIND VEL. PROFILE EXP.  0.2330
SKY CONDITION slight haze, Clear

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   17.16 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.6 M/SEC
AIR TEMPERATURE    79.5F DRY BULB   76.5F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               83.0                385.0E-06
   2               84.5                381.0E-06
   3               86.5                380.0E-06
   4               88.7                386.0E-06
   5               91.5                403.0E-06
   6               94.5                460.0E-06
   7               96.3                510.0E-06
   8               82.5                389.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       9.98700E-07 GRAM_MOLE_E
                   ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.1195   E-06 GRAM_MOLE_E
                    ACTUAL CUBIC METER
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              RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 01

DATE 6/28/73     START TIME 9:48 A.M.
SAMPLING LENGTH 65.0 MIN.


AIR STABILITY CATEGORY  2   WIND VEL. PROFILE EXP.  0.2300
SKY CONDITION  15% cloud cover plus light haze

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   14.15 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.9 M/SEC
AIR TEMPERATURE   83.0F DRY BULB   79.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1                89.1               388.0E-06
   2                90.6               400.0E-06
   3                93.2               433.0E-06
   4                94.9               470.0E-06
   5                97.7               560.0E-06
   6               100.8               700.0E-06
   7               102.6               805.0E-06
   8                88.3               385.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
        2.08200E-06 GRAM MOLE F
                    ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
        1.93396E-06 GRAM MOLE F
                    ACTUAL CUBIC METER
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         RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 02

DATE 6/28/73     START TIME 10:14 A.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  2   WIND VEL. PROFILE EXP.  0.2300
SKY CONDITION  20% cloud cover plus light haze

TIME AVERAGE WIND DIRECTION AT 3.05 METERS     9.67 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.9 M/SEC
AIR TEMPERATURE   83.0F DRY BULB   79.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               89.0                388.0E-06
   2               90.4                398.0E-06
   3               92.4                420.0E-06
   4               94.7                453.0E-06
   5               97.5                548.0E-06
   6              100.8                700.0E-06
   7              102.6                805.0E-06
   8               88.3                385.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.06300E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.06764E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
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        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 01

DATE 6/28/73    START TIME 11:00 A.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  2-3 WIND VEL. PROFILE EXP.  0.2350
SKY CONDITION 35% cloud cover plus light haze

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   -0.33 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.5 M/SEC
AIR TEMPERATURE   85.5F DRY BULB   79.5F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F DEG     VAPOR PRESSURE MM HG
   1              91.6                410.0E-06
   2              92.6                424.0E-06
   3              94.6                463.0E-06
   4              96.8                510.0E-06
   5              99.6                635.0E-06
   6             102.6                805.0E-06
   7             104.4                945.0E-06
   8              90.3                397.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       2.20500E-06 GRAM_MOLE_F
                   ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       2.2699  E-06 GRAM_MOLE_F
                    ACTUAL CUBIC METER
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           RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10    SAMPLER NUMBER 02

DATE   6/28/73    START TIME  11:24 A.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  2-3 WIND VEL. PROFILE EXP.  0.2300
SKY CONDITION 35% cloud cover light haze

TIME AVERAGE WIND DIRECTION AT 3.05 METERS    -5.00 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.4 M/SEC
AIR TEMPERATURE   85.5F DRY BULB   79.5F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               92.0              418.0E-06
   2               93.4              438.0E-06
   3               95.4              480.0E-06
   4               97.7              552.0E-06
   5              100.5              680.0E-06
   6              103.6              875.0E-06
   7              105.6              105.0E-05
   8               91.3              418.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     7.628000E-07 GRAM_MOLE_E
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     1.3461 E-06 GRAM_MOLE_E
                  ACTUAL CUBIC METER
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      RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 01

DATE 6/28/73    START TIME 12:09 A.M.
SAMPLING LENGTH 62.0 MIN.



AIR STABILITY CATEGORY  2   WIND VEL. PROFILE EXP.  0.2290
SKY CONDITION

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   -8.45 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.7 M/SEC
AIR TEMPERATURE   87.0F DRY BULB   78.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1                92.9              430.0E-06
   2                94.3              457.0E-06
   3                96.4              510.0E-06
   4                98.6              590.0E-06
   5               101.4              730.0E-06
   6               104.5              955.0E-06
   7               106.3              112.0E-05
   8                92.1              418.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.93500E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
        2.098 E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
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          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 1C   SAMPLER NUMBER 02

DATE 6/28/73    START TIME 12:33 P.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  2-3  WIND VEL. PROFILE EXP.  0.2280
SKY CONDITION   35% cloud cover plus light haze

TIME AVERAGE WIND DIRECTION AT 3.05 METERS  -11.17 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.7 M/SEC
AIR TEMPERATURE   87.0F DRY BULB   78.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT     TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1              92.9               430.0E-06
   2              94.3               457.0E-06
   3              96.4               510.0E-06
   4              98.8               590.0E-06
   5             101.4               730.0E-06
   6             104.5               955.0E-06
   7             106.3               112.0E-05
   8              92.1               418.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.60100E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.0954 E-06   GRAM_MOLE_F
                  ACTUAL CUBIC METER
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        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 01

DATE 6/28/73    START TIME 1:22 P.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  2-3  WIND VEL. PROFILE EXP.  0.2270
SKY CONDITION 50% cloud cover plus light haze

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   -5.33 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.8 M/SEC
AIR TEMPERATURE   88.0F DRY BULB   78.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               94.8              470.0E-06
   2               96.2              500.0E-06
   3               98.1              570.0E-06
   4              100.4              670.0E-06
   5              103.1              840.0E-06
   6              106.0              110.0E-05
   7              107.8              125.0E-05
   8               94.2              450.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.15100E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.326   E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
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           RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
 DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

 POND LOCATION CODE 10    SAMPLER NUMBER 02

 DATE 6/28/73      START TIME 1:52 P.M.
 SAMPLING LENGTH 65.0 MIN.


 AIR STABILITY CATEGORY  2-3  WIND VEL. PROFILE EXP.  0.2360
 SKY CONDITION   50% cloud cover plus light haze

 TIME AVERAGE WIND DIRECTION AT 3.05 METERS   -4.31 DEGREES
 TIME AVERAGE WIND SPEED AT 3.05 METERS   2.7 M/SEC
 AIR TEMPERATURE    88.0F DRY BULB   78.0F WET BULB


 POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

 SEGMENT      TEMPERATURE F.DEG      VAPOR PRESSURE MM HG
    1              96.6                 515.0E-06
    2              98.0                 565.0E-06
    3              99.8                 650.0E-06
    4             102.0                 765.0E-06
    5             104.5                 955.0E-06
    6             107.2                 122.0E-05
    7             108.8                 142.0E-05
    8              95.8                 492.0E-06

 MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.35200E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

 CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.6724  E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
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             RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
   DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

   POND LOCATION CODE 10   SAMPLER NUMBER 01

   DATE 6/28/73    START TIME 2:29 P.M.
   SAMPLING LENGTH 60.0 MIN.


   AIR STABILITY CATEGORY  3   WIND VEL. PROFILE EXP.  0.2270
   SKY CONDITION 50% cloud cover plus light haze

   TIME AVERAGE WIND DIRECTION AT 3.05 METERS   10.50 DEGREES
   TIME AVERAGE WIND SPEED AT 3.05 METERS   2.8 M/SEC
   AIR TEMPERATURE   89.5F DRY BULB   78.0F WET BULB


   POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

   SEGMENT     TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
      1              96.6              515.0E-06
      2              98.0              565.0E-06
      3              99.8              650.0E-06
      4             102.0              765.0E-06
      5             104.5              955.0E-06
      6             107.2              122.0E-05
      7             108.6              142.0E-05
      8              95.8              492.0E-06

   MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
        3.15300E-06 GRAM_MOLE_F
                    ACTUAL CUBIC METER

   CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
        3.46487E-06 GRAM_MOLE_F
                    ACTUAL CUBIC METER
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         RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 02

DATE 6/28/73     START TIME 3:06 P.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  3   WIND VEL. PROFILE EXP.  0.2280
SKY CONDITION 60% cloud cover; with high haze; rain squalls after
                                                      4:00 p.m.
TIME AVERAGE WIND DIRECTION AT 3.05 METERS   45.49 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   3.4 M/SEC
AIR TEMPERATURE    89.5F DRY BULB   78.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               96.6                515.0E-06
   2               98.0                565.0E-06
   3               99.8                650.0E-06
   4              102.0                765.0E-06
   5              104.5                955.0E-06
   6              107.2                122.0E-05
   7              108.8                142.0E-05
   8               95.8                492.0E-06


MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.00000E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.82050E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
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        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 10   SAMPLER NUMBER 02

DATE 6/28/73     START TIME 4:37 P.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  3-4 WIND VEL. PROFILE EXP.  0.2280
SKY CONDITION 50% cloud cover plus light haze

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   75.66 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   3.7 M/SEC
AIR TEMPERATURE   88.5F DRY BULB   77.5F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT       TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1                98.1             565.0E-06
   2                99.5             630.0E-06
   3               101.3             725.0E-06
   4               103.5             870.0E-06
   5               106.0             109.0E-05
   6               108.3             137.0E-05
   7               110.3             162.0E-05
   8                97.3             540.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.96600E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.1111e-06   GRAM_MOLE_F
                  ACTUAL CUBIC METER
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         RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 01

DATE 6/28/73     START TIME 5:04 P.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  3-4  WIND VEL. PROFILE EXP.  0.2220
SKY CONDITION Partially sunny; 50% cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   69.49 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   4.1 M/SEC
AIR TEMPERATURE   85.5F DRY BULB   76.5F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1              98.1               565.0E-06
   2              99.5               630.0E-06
   3             101.3               725.0E-06
   4             103.5               870.0E-06
   5             106.0               109.0E-05
   6             108.7               137.0E-05
   7             110.3               162.0E-05
   8              97.3               540.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      4.12600E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.6947  E-06 GRAM_MOLE_F
                   ACTUAL CUBIC METER
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        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 1C   SAMPLER NUMBER 02

DATE  6/29/73   START TIME  9:59 A.M.
SAMPLING LENGTH 65.0 MIN.


AIR STABILITY CATEGORY 3-4   WIND VEL. PROFILE EXP.  0.2310
SKY CONDITION 100 to 60% low cloud cover; shut down during 1 hour
              rain storm middle of run
TIME AVERAGE WIND DIRECTION AT 3.05 METERS    19.54 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS    3.6 M/SEC
AIR TEMPERATURE    83.5F DRY BULB   81.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT     TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1              87.8              383.0E-06
   2              88.9              387.0E-06
   3              90.6              400.0E-06
   4              92.6              425.0E-06
   5              95.1              474.0E-06
   6              98.0              565.0E-06
   7              99.8              645.0E-06
   8              87.4              381.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.88700E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.33908E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
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          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 01

DATE  6/29/73   START TIME  10:10 A.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.2330
SKY CONDITION 100 to 60% low cloud cover; one hour rain storms between
              10:20 and 11:20 (sampling halted during storm)
TIME AVERAGE WIND DIRECTION AT 3.05 METERS   18.83 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   3.4 M/SEC
AIR TEMPERATURE   83.5F DRY BULB   81.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1               87.8              383.0E-06
   2               88.9              387.0E-06
   3               90.6              400.0E-06
   4               92.6              425.0E-06
   5               95.1              474.0E-06
   6               98.0              565.0E-06
   7               99.0              645.0E-06
   8               87.4              381.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.40700E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.52823E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
```

15.4.2 Pond 20 Downwind

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           RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
     DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

     POND LOCATION CODE 20    SAMPLER NUMBER 01

     DATE   8/15/73    START TIME  9:37 A.M.
     SAMPLING LENGTH 60.0 MIN.


     AIR STABILITY CATEGORY  1    WIND VEL. PROFILE EXP.  0.2550
     SKY CONDITION Sunny 10% high cloud cover

     TIME AVERAGE WIND DIRECTION AT 3.05 METERS   39.16 DEGREES
     TIME AVERAGE WIND SPEED AT 3.05 METERS   1.3 M/SEC
     AIR TEMPERATURE    78.5F DRY BULB   75.5F WET BULB


     POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

     SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
        1               95.4               440.0E-06
        2               94.6               432.0E-06
        3               93.8               426.0E-06
        4               92.5               411.0E-06
        5               91.1               400.0E-06
        6               90.0               391.0E-06
        7               89.0               388.0E-06
        8               87.8               382.0E-06
        9               87.8               382.0E-06

     MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
           1.16000E-06 GRAM_MOLE_F
                       ACTUAL CUBIC METER

     CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
           1.14163E-06 GRAM_MOLE_F
                       ACTUAL CUBIC METER
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         RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 20   SAMPLER NUMBER 01

DATE  8/15/73   START TIME  10:42 A.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  1   WIND VEL. PROFILE EXP.  0.2490
SKY CONDITION  Sunny 20% high cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   35.83 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.5 M/SEC
AIR TEMPERATURE    84.0F DRY BULB   79.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1              96.4               455.0E-06
   2              95.6               446.0E-06
   3              94.8               438.0E-06
   4              93.5               421.0E-06
   5              92.1               409.0E-06
   6              91.0               400.0E-06
   7              90.0               391.0E-06
   8              88.6               388.0E-06
   9              88.8               388.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      9.02400E-07 GRAM MOLE F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.02877E-06 GRAM MOLE F
                  ACTUAL CUBIC METER
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        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 20   SAMPLER NUMBER 01

DATE  8/15/73   START TIME  1:10 P.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  1-2  WIND VEL. PROFILE EXP.  0.2350
SKY CONDITION Sunny; 20 to 50% middle cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   -5.00 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.0 M/SEC
AIR TEMPERATURE   89.0F DRY BULB   79.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG      VAPOR PRESSURE MM HG
   1              104.5               603.0E-06
   2              103.4               568.0E-06
   3              102.3               555.0E-06
   4              100.3               517.0E-06
   5               98.3               480.0E-06
   6               96.5               458.0E-06
   7               95.2               440.0E-06
   8               93.6               420.0E-06
   9               93.6               420.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       6.56500E-07 GRAM_MOLE_E
                   ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       4.9983  E-07 GRAM_MOLE_E
                    ACTUAL CUBIC METER
       RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 02

DATE  8/15/73   START TIME  1:09 P.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  1-2  WIND VEL. PROFILE EXP.  0.2350
SKY CONDITION Sunny; 20 to 50% middle cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   -5.00 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.0 M/SEC
AIR TEMPERATURE   89.0F DRY BULB   79.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               104.5              603.0E-06
   2               103.4              568.0E-06
   3               102.3              555.0E-06
   4               100.3              517.0E-06
   5                98.3              480.0E-06
   6                96.5              458.0E-06
   7                95.2              440.0E-06
   8                93.6              420.0E-06
   9                93.6              420.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       1.37600E-06 GRAM MOLE F
                   ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       1.7537  E-06 GRAM MOLE F
                   ACTUAL CUBIC METER
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           RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
     DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


     POND LOCATION CODE 20   SAMPLER NUMBER 01

     DATE  8/15/73   START TIME  2:20 P.M.
     SAMPLING LENGTH 60.0 MIN.



     AIR STABILITY CATEGORY  1-2  WIND VEL. PROFILE EXP.  0.2320
     SKY CONDITION Sunny; 50% middle cloud cover

     TIME AVERAGE WIND DIRECTION AT 3.05 METERS    6.67 DEGREES
     TIME AVERAGE WIND SPEED AT 3.05 METERS   2.0 M/SEC
     AIR TEMPERATURE   96.0F DRY BULB   82.0F WET BULB



     POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

     SEGMENT     TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
        1              104.5              603.0E-06
        2              103.4              568.0E-06
        3              102.3              555.0E-06
        4              100.3              517.0E-06
        5               98.3              480.0E-06
        6               96.5              458.0E-06
        7               95.2              440.0E-06
        8               93.6              420.0E-06
        9               93.6              420.0E-06

     MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
           5.30500E-07 GRAM_MOLE_F
                       ACTUAL CUBIC METER

     CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
           8.2618  E-07 GRAM_MOLE_F
                       ACTUAL CUBIC METER
        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 02

DATE  8/15/73   START TIME  2:20 P.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  1-2  WIND VEL. PROFILE EXP.  0.2320
SKY CONDITION Sunny; 50% middle cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   15.00 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.0 M/SEC
AIR TEMPERATURE   96.0F DRY BULB   82.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT     TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1             104.5                603.0E-06
   2             103.4                568.0E-06
   3             102.3                555.0E-06
   4             100.3                517.0E-06
   5              98.3                480.0E-06
   6              96.5                458.0E-06
   7              95.2                440.0E-06
   8              93.6                420.0E-06
   9              93.6                420.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.24700E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.1718   E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
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          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
  DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

  POND LOCATION CODE 20   SAMPLER NUMBER 01

  DATE  8/16/73   START TIME  8:49 A.M.
  SAMPLING LENGTH 60.0 MIN.


  AIR STABILITY CATEGORY  1-2 WIND VEL. PROFILE EXP.  0.2450
  SKY CONDITION Sunny; 0% cloud cover

  TIME AVERAGE WIND DIRECTION AT 3.05 METERS   44.99 DEGREES
  TIME AVERAGE WIND SPEED AT 3.05 METERS   1.9 M/SEC
  AIR TEMPERATURE   81.0F DRY BULB   77.0F WET BULB


  POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

  SEGMENT     TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
     1              90.0               391.0E-06
     2              89.9               390.0E-06
     3              89.5               390.0E-06
     4              88.9               389.0E-06
     5              88.3               388.0E-06
     6              87.6               382.0E-06
     7              87.2               381.0E-06
     8              86.8               380.0E-06
     9              86.8               380.0E-06

  MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       1.08300E-06 GRAM_MOLE_F
                   ACTUAL CUBIC METER

  CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       1.3629  E-06 GRAM_MOLE_F
                   ACTUAL CUBIC METER
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         RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 20   SAMPLER NUMBER 01

DATE  8/16/73   START TIME  9:57 A.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  1   WIND VEL. PROFILE EXP.  0.2530
SKY CONDITION    Sunny 0 to 5% high cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   32.50 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.5 M/SEC
AIR TEMPERATURE   83.0F DRY BULB   78.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT     TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1              91.2              401.0E-06
   2              90.7              396.0E-06
   3              90.3              395.0E-06
   4              89.6              390.0E-06
   5              89.2              388.0E-06
   6              87.9              383.0E-06
   7              87.3              382.0E-06
   8              86.8              381.0E-06
   9              86.8              381.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      8.14600E-07 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      9.68466E-07 GRAM_MOLE_F
                  ACTUAL CUBIC METER
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          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
    DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 02

DATE  8/16/73   START TIME  10:05 A.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  1   WIND VEL. PROFILE EXP.  0.2530
SKY CONDITION  Sunny; 0 to 5% high cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   32.50 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.5 M/SEC
AIR TEMPERATURE   83.0F DRY BULB   78.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1                91.2              401.0E-06
   2                90.7              396.0E-06
   3                90.3              395.0E-06
   4                89.6              390.0E-06
   5                89.2              388.0E-06
   6                87.3              383.0E-06
   7                86.8              382.0E-06
   8                86.8              381.0E-06
   9                 0.0              381.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       1.33700E-06 GRAM MOLE F
                   ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       1.24061E-06 GRAM MOLE F
                   ACTUAL CUBIC METER
          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 20   SAMPLER NUMBER 01

DATE  8/16/73   START TIME  11:15 A.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  1   WIND VEL. PROFILE EXP.  0.2500
SKY CONDITION   Sunny 10 to 50% midheight cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   31.66 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.5 M/SEC
AIR TEMPERATURE   86.0F DRY BULB   79.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1              94.3                430.0E-06
   2              93.5                421.0E-06
   3              92.8                417.0E-06
   4              91.6                404.0E-06
   5              90.5                396.0E-06
   6              89.5                390.0E-06
   7              88.6                387.0E-06
   8              88.1                383.0E-06
   9              88.1                383.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      7.52300E-07 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.03727E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
```

RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 02

DATE 8/16/73   START TIME 11:15 A.M.
SAMPLING LENGTH 60.0 MIN.

AIR STABILITY CATEGORY 1   WIND VEL. PROFILE EXP. 0.2500
SKY CONDITION Sunny; 10 to 50% midheight cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   32.50 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.5 M/SEC
AIR TEMPERATURE   86.0F DRY BULB   79.0F WET BULB

POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT	TEMPERATURE F.DEG	VAPOR PRESSURE MM HG
1	94.3	430.0E-06
2	93.5	421.0E-06
3	92.8	417.0E-06
4	91.6	404.0E-06
5	90.5	396.0E-06
6	89.5	390.0E-06
7	88.6	387.0E-06
8	88.1	383.0E-06
9	88.1	383.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION

$$1.05600E-06 \ \frac{\text{GRAM MOLE F}}{\text{ACTUAL CUBIC METER}}$$

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION

$$1.33679E-06 \ \frac{\text{GRAM MOLE F}}{\text{ACTUAL CUBIC METER}}$$

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          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 01

DATE  8/16/73   START TIME  12:25 P.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  1   WIND VEL. PROFILE EXP.  0.2340
SKY CONDITION  Sunny 50% midheight cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   39.16 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.9 M/SEC
AIR TEMPERATURE   88.0F DRY BULB   79.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               99.3               500.0E-06
   2               98.3               480.0E-06
   3               97.4               469.0E-06
   4               95.7               447.0E-06
   5               94.1               428.0E-06
   6               92.6               412.0E-06
   7               91.5               403.0E-06
   8               90.0               391.0E-06
   9               90.0               391.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.05500E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.11468E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
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       RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 20   SAMPLER NUMBER 02

DATE  8/16/73   START TIME  12:26 P.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  1   WIND VEL. PROFILE EXP.  0.2340
SKY CONDITION  Sunny  50% midheight cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   40.00 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.9 M/SEC
AIR TEMPERATURE   88.0F DRY BULB   79.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT     TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               99.3              500.0E-06
   2               98.3              480.0E-06
   3               97.4              469.0E-06
   4               95.7              447.0E-06
   5               94.1              428.0E-06
   6               92.6              412.0E-06
   7               91.5              403.0E-06
   8               90.0              391.0E-06
   9               90.0              391.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.22200E-06 GRAM MOLE F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.31222E-06 GRAM MOLE F
                  ACTUAL CUBIC METER
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RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 02

DATE 8/16/73   START TIME 1:49 P.M.
SAMPLING LENGTH 60.0 MIN.

AIR STABILITY CATEGORY 1   WIND VEL. PROFILE EXP. 0.2400
SKY CONDITION Sunny; 50% mid height cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   -9.17 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.5 M/SEC
AIR TEMPERATURE   93.0F DRY BULB   81.0F WET BULB

POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT	TEMPERATURE F.DEG	VAPOR PRESSURE MM HG
1	102.1	550.0E-06
2	101.0	528.0E-06
3	100.0	510.0E-06
4	98.2	480.0E-06
5	96.3	453.0E-06
6	94.8	437.0E-06
7	93.6	422.0E-06
8	92.3	410.0E-06
9	92.3	410.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION

$$1.46800\text{E-}06\ \frac{\text{GRAM MOLE F}}{\text{ACTUAL CUBIC METER}}$$

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION

$$1.18911\text{E-}06\ \frac{\text{GRAM MOLE F}}{\text{ACTUAL CUBIC METER}}$$

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         RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 2C    SAMPLER NUMBER 01

DATE  8/17/73   START TIME  9:40 P.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  2   WIND VEL. PROFILE EXP.  0.2390
SKY CONDITION  Sunny  10 to 30% high cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   80.49 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.3 M/SEC
AIR TEMPERATURE   83.0F DRY BULB   80.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT     TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1             100.9                525.0E-06
   2              99.5                500.0E-06
   3              98.2                480.0E-06
   4              95.9                448.0E-06
   5              93.7                423.0E-06
   6              91.8                480.0E-06
   7              90.4                395.0E-06
   8              88.7                387.0E-06
   9              88.7                387.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     1.16300E-06 GRAM_MOLE_F
                 ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     1.68091E-06 GRAM_MOLE_F
                 ACTUAL CUBIC METER
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RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 02

DATE 8/17/73   START TIME 9:42 A.M.
SAMPLING LENGTH 60.0 MIN.

AIR STABILITY CATEGORY 2   WIND VEL. PROFILE EXP. 0.2390
SKY CONDITION Sunny   10 to 30% high cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   80.49 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.3 M/SEC
AIR TEMPERATURE   83.0F DRY BULB   80.0F WET BULB

POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT	TEMPERATURE F.DEG	VAPOR PRESSURE MM HG
1	100.9	525.0E-06
2	99.5	500.0E-06
3	98.2	480.0E-06
4	95.9	448.0E-06
5	93.7	423.0E-06
6	91.8	408.0E-06
7	90.4	395.0E-06
8	88.7	387.0E-06
9	88.7	387.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
1.24700E-06 GRAM MOLE F / ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
7.25986E-07 GRAM MOLE F / ACTUAL CUBIC METER

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         RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 01

DATE  8/17/73   START TIME  10:48 A.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  2   WIND VEL. PROFILE EXP.  0.2270
SKY CONDITION  Sunny  30 to 50% midheight cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   83.32 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.8 M/SEC
AIR TEMPERATURE   86.0F DRY BULB   80.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT     TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1             102.9              568.0E-06
   2             101.5              539.0E-06
   3             100.2              512.0E-06
   4              97.9              475.0E-06
   5              95.7              445.0E-06
   6              93.9              427.0E-06
   7              92.4              410.0E-06
   8              90.7              395.0E-06
   9              90.7              395.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     1.63700E-06 GRAM-MOLE F
                 ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     1.58740E-06 GRAM-MOLE F
                 ACTUAL CUBIC METER
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          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 01

DATE  8/17/73   START TIME  12:20 P.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  2   WIND VEL. PROFILE EXP.  0.2250
SKY CONDITION  Sunny  50 to 70% midheight cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   77.99 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.9 M/SEC
AIR TEMPERATURE   89.0F DRY BULB   81.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT       TEMPERATURE F.DEG      VAPOR PRESSURE MM HG
  1                104.1                 592.0E-06
  2                102.9                 568.0E-06
  3                101.7                 540.0E-06
  4                 99.7                 502.0E-06
  5                 97.6                 471.0E-06
  6                 95.9                 448.0E-06
  7                 94.5                 432.0E-06
  8                 92.7                 414.0E-06
  9                 92.7                 414.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     1.82100E-06 GRAM_MOLE_F
                 ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     1.70660E-06 GRAM_MOLE_F
                 ACTUAL CUBIC METER
          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
  DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 01

DATE  8/17/17   START TIME   1:30 P.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  2   WIND VEL. PROFILE EXP.  0.2310
SKY CONDITION   Sunny 60% midheight cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   74.99 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   3.0 M/SEC
AIR TEMPERATURE   90.0F DRY BULB   81.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG      VAPOR PRESSURE MM HG
   1               104.1               592.0E-06
   2               102.9               563.0E-06
   3               101.7               540.0E-06
   4                99.7               502.0E-06
   5                97.6               471.0E-06
   6                95.9               448.0E-06
   7                94.5               432.0E-06
   8                92.7               414.0E-06
   9                92.7               414.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     1.75100E-06 GRAM_MOLE_E
                 ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     1.72829E-06 GRAM_MOLE_E
                 ACTUAL CUBIC METER
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         RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 01

DATE  8/17/73   START TIME  2:37 P.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  2   WIND VEL. PROFILE EXP.  0.2310
SKY CONDITION  Sunny 60% midheight cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   73.32 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   3.0 M/SEC
AIR TEMPERATURE   91.0F DRY BULB   80.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1              104.1              592.0E-06
   2              102.9              568.0E-06
   3              101.7              540.0E-06
   4               99.7              502.0E-06
   5               97.6              471.0E-06
   6               95.9              448.0E-06
   7               94.5              432.0E-06
   8               92.7              414.0E-06
   9               92.7              414.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.98000E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.73778E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
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        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 20   SAMPLER NUMBER 01

DATE  8/18/73    START TIME  9:33 A.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  2   WIND VEL. PROFILE EXP.  0.2240
SKY CONDITION  Sunny 5 to 10% high cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   84.32 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   3.2 M/SEC
AIR TEMPERATURE   84.0F DRY BULB   80.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG      VAPOR PRESSURE MM HG
   1               99.1                 492.0E-06
   2               98.0                 478.0E-06
   3               96.9                 460.0E-06
   4               95.0                 438.0E-06
   5               93.1                 420.0E-06
   6               91.6                 402.0E-06
   7               89.9                 391.0E-06
   8               88.5                 385.0E-06
   9               88.5                 385.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.55800E-06 GRAM-MOLE-F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.47713E-06 GRAM-MOLE-F
                  ACTUAL CUBIC METER
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          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 01

DATE  8/18/73   START TIME  10:40 A.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  2   WIND VEL. PROFILE EXP.  0.2210
SKY CONDITION   Sunny  10 to 30% midheight cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   97.99 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   3.2 M/SEC
AIR TEMPERATURE   87.0F DRY BULB   80.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               101.1             530.0E-06
   2                99.0             492.0E-06
   3                97.6             470.0E-06
   4                96.0             459.0E-06
   5                94.1             430.0E-06
   6                92.6             413.0E-06
   7                90.9             398.0E-06
   8                89.5             390.0E-06
   9                89.5             390.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.63400E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.53005E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 20   SAMPLER NUMBER 01

DATE  8/18/73   START TIME  12:00 N.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  2   WIND VEL. PROFILE EXP.  0.2260
SKY CONDITION    Sunny  30 to 60% midheight cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   87.32 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.8 M/SEC
AIR TEMPERATURE   91.0F DRY BULB   80.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1              103.3               575.0E-06
   2              102.1               550.0E-06
   3              101.5               539.0E-06
   4               99.9               508.0E-06
   5               98.0               478.0E-06
   6               96.6               457.0E-06
   7               95.4               442.0E-06
   8               93.9               427.0E-06
   9               93.9               427.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.71700E-06 GRAM MOLE F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.80186E-06 GRAM MOLE F
                  ACTUAL CUBIC METER
          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
  DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

  POND LOCATION CODE 20   SAMPLER NUMBER 01

  DATE  8/18/73   START TIME  1:10 P.M.
  SAMPLING LENGTH 60.0 MIN.


  AIR STABILITY CATEGORY  2-3  WIND VEL. PROFILE EXP.  0.2300
  SKY CONDITION Partially sunny; 60% mid-height cloud cover

  TIME AVERAGE WIND DIRECTION AT 3.05 METERS  100.65 DEGREES
  TIME AVERAGE WIND SPEED AT 3.05 METERS   2.8 M/SEC
  AIR TEMPERATURE   91.0F DRY BULB   81.0F WET BULB


  POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

  SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
     1               104.3              600.0E-06
     2               103.1              570.0E-06
     3               102.5              560.0E-06
     4               100.9              524.0E-06
     5                99.0              492.0E-06
     6                97.6              470.0E-06
     7                96.4              453.0E-06
     8                94.9              437.0E-06
     9                94.9              437.0E-06

 MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       1.70900E-06 GRAM_MOLE_E
                   ACTUAL CUBIC METER

 CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.2197   E-06 GRAM_MOLE_E
                   ACTUAL CUBIC METER
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           RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 2C    SAMPLER NUMBER 01

DATE  8/19/73    START TIME  9:25 A.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  1-2  WIND VEL. PROFILE EXP.  0.2570
SKY CONDITION Slight haze; 30 to 60% midheight cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS    94.99 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.2 M/SEC
AIR TEMPERATURE   83.0F DRY BULB   81.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT        TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1                97.8               472.0E-06
   2                96.7               459.0E-06
   3                95.8               447.0E-06
   4                94.3               430.0E-06
   5                92.8               416.0E-06
   6                91.4               400.0E-06
   7                90.4               392.0E-06
   8                89.0               388.0E-06
   9                89.0               388.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.29900E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.5874  E-06 GRAM_MOLE_F
                   ACTUAL CUBIC METER
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        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 01

DATE  8/19/73   START TIME  10:30 A.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  1-2  WIND VEL. PROFILE EXP.  0.2530
SKY CONDITION 60 to 50% midheight cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS  105.82 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.4 M/SEC
AIR TEMPERATURE   85.0F DRY BULB   80.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1              99.8                505.0E-06
   2              98.7                488.0E-06
   3              97.8                475.0E-06
   4              96.3                454.0E-06
   5              94.8                438.0E-06
   6              93.4                420.0E-06
   7              92.4                410.0E-06
   8              91.0                400.0E-06
   9              91.0                400.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      8.78200E-07 GRAM_MOLE_E
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.5199 E-06 GRAM_MOLE_E
                  ACTUAL CUBIC METER
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         RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 01

DATE  8/19/73    START TIME  11:36 A.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  1   WIND VEL. PROFILE EXP.  0.2500
SKY CONDITION  50 to 40% mid height cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   89.99 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.4 M/SEC
AIR TEMPERATURE   88.0F DRY BULB   80.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1              101.8                543.0E-06
   2              100.7                522.0E-06
   3               99.8                505.0E-06
   4               98.3                480.0E-06
   5               96.8                460.0E-06
   6               95.4                442.0E-06
   7               94.4                430.0E-06
   8               93.0                418.0E-06
   9               93.0                418.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      9.90900E-07 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.43956E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
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          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
  DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

  POND LOCATION CODE 20   SAMPLER NUMBER 01

  DATE  8/19/73   START TIME  12:43 P.M.
  SAMPLING LENGTH 60.0 MIN.


  AIR STABILITY CATEGORY  1   WIND VEL. PROFILE EXP.  0.2460
  SKY CONDITION  Sunny; 50 to 70% midheight cloud cover

  TIME AVERAGE WIND DIRECTION AT 3.05 METERS  101.65 DEGREES
  TIME AVERAGE WIND SPEED AT 3.05 METERS   1.6 M/SEC
  AIR TEMPERATURE   89.0F DRY BULB   81.0F WET BULB


  POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

  SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
     1             103.8               588.0E-06
     2             102.7               560.0E-06
     3             101.8               545.0E-06
     4             100.3               515.0E-06
     5              98.8               490.0E-06
     6              97.4               468.0E-06
     7              96.4               452.0E-06
     8              95.0               439.0E-06
     9              95.0               439.0E-06

  MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
        1.31000E-06 GRAM_MOLE_F
                    ACTUAL CUBIC METER

  CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
        1.47435E-06 GRAM_MOLE_F
                    ACTUAL CUBIC METER
        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 20   SAMPLER NUMBER 01

DATE  8/20/73   START TIME  9:10 A.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  1-2  WIND VEL. PROFILE EXP.  0.2450
SKY CONDITION Sunny; slight haze; 30% midheight cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   90.49 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.9 M/SEC
AIR TEMPERATURE   82.0F DRY BULB   80.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT     TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1              89.0              388.0E-06
   2              89.0              388.0E-06
   3              89.0              388.0E-06
   4              89.0              388.0E-06
   5              89.0              388.0E-06
   6              89.0              388.0E-06
   7              89.0              388.0E-06
   8              89.0              388.0E-06
   9              89.0              388.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.06300E-06 GRAM MOLE F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1. 3321 E-06 GRAM MOLE F
                   ACTUAL CUBIC METER
        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 20   SAMPLER NUMBER 02

DATE  8/20/73   START TIME   9:31 A.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  1-2  WIND VEL. PROFILE EXP.  0.2450
SKY CONDITION Sunny, slight haze; 30% midheight cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   84.66 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.0 M/SEC
AIR TEMPERATURE   82.0F DRY BULB   80.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               89.0               388.0E-06
   2               89.0               388.0E-06
   3               89.0               388.0E-06
   4               89.0               388.0E-06
   5               89.0               388.0E-06
   6               89.0               388.0E-06
   7               89.0               388.0E-06
   8               89.0               388.0E-06
   9               89.0               388.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      6.86700E-07 GRAM MOLE F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      4.2480    -07 GRAM MOLE F
                  ACTUAL CUBIC METER
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         RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 20   SAMPLER NUMBER 01

DATE  8/20/73   START TIME  10:35 A.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  1-2  WIND VEL. PROFILE EXP.  0.2430
SKY CONDITION Sunny; 40% midheight cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   84.99 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.8 M/SEC
AIR TEMPERATURE   85.0F DRY BULB   80.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT     TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1              90.5              395.0E-06
   2              90.5              395.0E-06
   3              90.5              395.0E-06
   4              90.5              395.0E-06
   5              90.5              395.0E-06
   6              90.5              395.0E-06
   7              90.5              395.0E-06
   8              90.5              395.0E-06
   9              90.5              395.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      9.43600E-07 GRAM-MOLE
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.4293 E-06 GRAM-MOLE
                  ACTUAL CUBIC METER
```

```
          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 20   SAMPLER NUMBER 02

DATE  8/20/73   START TIME  10:38 A.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  1-2  WIND VEL. PROFILE EXP.  0.2430
SKY CONDITION Sunny; 40% midheight cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   84.99 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.8 M/SEC
AIR TEMPERATURE   85.0F DRY BULB   80.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT     TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1              90.5               395.0E-06
   2              90.5               395.0E-06
   3              90.5               395.0E-06
   4              90.5               395.0E-06
   5              90.5               395.0E-06
   6              90.5               395.0E-06
   7              90.5               395.0E-06
   8              90.5               395.0E-06
   9              90.5               395.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.00200E-06 GRAM MOLE F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      4.4878  E-07 GRAM MOLE F
                  ACTUAL CUBIC METER
```

```
       RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 20   SAMPLER NUMBER 01

DATE  8/20/73   START TIME  1:57 P.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  1   WIND VEL. PROFILE EXP.  0.2410
SKY CONDITION  60% to 50% mid height cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   95.82 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.7 M/SEC
AIR TEMPERATURE   92.0F DRY BULB   79.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT     TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1              96.5             457.0E-06
   2              96.5             457.0E-06
   3              96.5             457.0E-06
   4              96.5             457.0E-06
   5              96.5             457.0E-06
   6              96.5             457.0E-06
   7              96.5             457.0E-06
   8              96.5             457.0E-06
   9              96.5             457.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      5.81500E-07 GRAM MOLE F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      7.50059E-07 GRAM MOLE F
                  ACTUAL CUBIC METER
```

```
          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 01

DATE  8/21/73   START TIME  9:15 A.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  5   WIND VEL. PROFILE EXP.  0.2680
SKY CONDITION    Ground fog; 100% mid height cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS -106.65 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.2 M/SEC
AIR TEMPERATURE   78.0F DRY BULB   77.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               90.2               392.0E-06
   2               89.8               391.0E-06
   3               89.5               390.0E-06
   4               88.9               388.0E-06
   5               88.3               384.0E-06
   6               87.6               381.0E-06
   7               87.2               381.0E-06
   8               86.8               381.0E-06
   9               86.8               381.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.95800E-07 GRAM MOLE F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.45543E-08 GRAM MOLE F
                  ACTUAL CUBIC METER
```

```
        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 02

DATE  8/21/73   START TIME  9:19 A.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  5   WIND VEL. PROFILE EXP.  0.2680
SKY CONDITION Ground fog, 100% mid height cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS -106.65 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.2 M/SEC
AIR TEMPERATURE   78.0F DRY BULB   77.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT     TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1              90.2              392.0E-06
   2              89.8              391.0E-06
   3              89.5              390.0E-06
   4              88.9              388.0E-06
   5              88.3              384.0E-06
   6              87.6              381.0E-06
   7              87.2              381.0E-06
   8              86.8              381.0E-06
   9              86.8              381.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      5.33100E-07 GRAM MOLE F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      0.0         GRAM MOLE F
                  ACTUAL CUBIC METER
```

```
         RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 01

DATE  8/21/73   START TIME  10:30 A.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  3   WIND VEL. PROFILE EXP.  0.2630
SKY CONDITION  Lifting ground fog; 100 to 80% mid height cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   51.66 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.6 M/SEC
AIR TEMPERATURE   80.0F DRY BULB   77.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1              90.2               392.0E-06
   2              89.9               391.0E-06
   3              89.5               390.0E-06
   4              88.9               388.0E-06
   5              88.3               384.0E-06
   6              87.6               381.0E-06
   7              87.2               381.0E-06
   8              86.8               381.0E-06
   9              86.8               381.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       3.45600E-07 GRAM MOLE F
                   ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       8.50991E-07 GRAM MOLE F
                   ACTUAL CUBIC METER
```

RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 02

DATE 8/21/73   START TIME 10:27 A.M.
SAMPLING LENGTH 60.0 MIN.

AIR STABILITY CATEGORY 3   WIND VEL. PROFILE EXP. 0.2680
SKY CONDITION   Lifting ground fog; 100 to 80% mid height cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   51.66 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.6 M/SEC
AIR TEMPERATURE   78.0F DRY BULB   77.0F WET BULB

POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT	TEMPERATURE F.DEG	VAPOR PRESSURE MM HG
1	90.2	392.0E-06
2	89.9	391.0E-06
3	89.5	390.0E-06
4	88.9	388.0E-06
5	88.3	384.0E-06
6	87.6	381.0E-06
7	87.2	381.0E-06
8	86.8	381.0E-06
9	86.8	381.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION

$$3.67200E-07 \ \frac{\text{GRAM MOLE F}}{\text{ACTUAL CUBIC METER}}$$

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION

$$0.0 \ \frac{\text{GRAM MOLE F}}{\text{ACTUAL CUBIC METER}}$$

15.4.3 Pond 10 Upwind Sampler - 03

```
        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 03

DATE  6/21/73   START TIME  10:43 A.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.2350
SKY CONDITION  Overcast - Showers

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   28.00 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.8 M/SEC
AIR TEMPERATURE    80.0F DRY BULB   UNK. F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1              90.3               397.0E-06
   2              91.4               408.0E-06
   3              92.9               430.0E-06
   4              94.6               462.0E-06
   5              96.7               520.0E-06
   6              99.0               610.0E-06
   7             100.4               673.0E-06
   8              89.7               390.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     0.0          GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     0.0          GRAM_MOLE_F
                  ACTUAL CUBIC METER
        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 10   SAMPLER NUMBER 03

DATE  6/21/73   START TIME  5:12 P.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  3   WIND VEL. PROFILE EXP.  0.2210
SKY CONDITION       95% overcast

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   47.16 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   3.7 M/SEC
AIR TEMPERATURE   81.5F DRY BULB   79.5F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1                89.5             410.0E-06
   2                90.9             431.0E-06
   3                92.6             470.0E-06
   4                94.8             535.0E-06
   5                97.4             650.0E-06
   6               100.5             830.0E-06
   7               102.3             980.0E-06
   8                89.0             400.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      0.0          GRAM_MOLE_F
                   ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      0.0          GRAM_MOLE_F
                   ACTUAL CUBIC METER
        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 03

DATE  6/22/83   START TIME  3:47 P.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.2090
SKY CONDITION 90% overcast - mixed mid and low cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   29.66 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   4.4 M/SEC
AIR TEMPERATURE   91.5F DRY BULB   77.5F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT     TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1               93.3             438.0E-06
   2               95.0             472.0E-06
   3               97.0             530.0E-06
   4              100.3             670.0E-06
   5              103.8             900.0E-06
   6              107.9             130.0E-05
   7              110.3             162.0E-05
   8               92.4             420.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      0.0          GRAM_MOLE_F
                   ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      0.0          GRAM_MOLE_F
                   ACTUAL CUBIC METER
        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 03

DATE  6/28/73   START TIME  10:26 A.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  3   WIND VEL. PROFILE EXP.  0.2280
SKY CONDITION  25% cloud cover plus light haze

TIME AVERAGE WIND DIRECTION AT 3.05 METERS    5.50 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.9 M/SEC
AIR TEMPERATURE    83.0F DRY BULB   79.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               89.1                388.0E-06
   2               90.6                400.0E-06
   3               93.2                433.0E-06
   4               94.7                470.0E-06
   5               97.7                560.0E-06
   6              100.9                700.0E-06
   7              102.6                805.0E-06
   8               88.3                385.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      9.23900E-07 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      0.0         GRAM_MOLE_F
                  ACTUAL CUBIC METER
        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 03

DATE  6/28/73    START TIME  3:59 P.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.2000
SKY CONDITION   50% cloud cover plus light haze

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   82.49 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   4.8 M/SEC
AIR TEMPERATURE   85.5F DRY BULB   76.5F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1                98.1             565.0E-06
   2                99.5             630.0E-06
   3               101.3             725.0E-06
   4               103.5             870.0E-06
   5               106.0             109.0E-05
   6               108.7             137.0E-05
   7               110.3             162.0E-05
   8                97.3             540.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.05700E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.99353E-07 GRAM_MOLE_F
                  ACTUAL CUBIC METER
```

```
          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 1C   SAMPLER NUMBER 03

DATE  6/29/73   START TIME  11:22 A.M.
SAMPLING LENGTH 53.0 MIN.



AIR STABILITY CATEGORY  3   WIND VEL. PROFILE EXP.  0.2320
SKY CONDITION 60% cloud cover - one hour rain squall just over

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   18.56 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   3.3 M/SEC
AIR TEMPERATURE   83.5F DRY BULB   81.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT     TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1              87.8               383.0E-06
   2              88.9               387.0E-06
   3              90.6               400.0E-06
   4              92.6               425.0E-06
   5              95.1               474.0E-06
   6              98.0               565.0E-06
   7              99.8               645.0E-06
   8              87.4               381.0E-06


MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      6.78000E-07 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      0.0         GRAM_MOLE_F
                  ACTUAL CUBIC METER
```

15.5 Unusable Ambient Air Fluorine Concentration Measurements

The measurements tabled in this appendix were not used in developing the correlations shown in Figures 10.1 and 10.2 for a number of reasons. Each reason is covered separately on the page just before the data sheets describing the unused runs.

15.5.1 Pond 10

Concentrations measured by sampler 01, the sampler nearest the pond when the wind velocity was over 5 meters/sec are considerably higher than the predicted values, Figure 15.4. Since measurements made with sampler 02 during the same period did not show this trend and no entrainment was noted, it is likely that the dispersion model cannot handle the combination of high wind speeds and short distances.

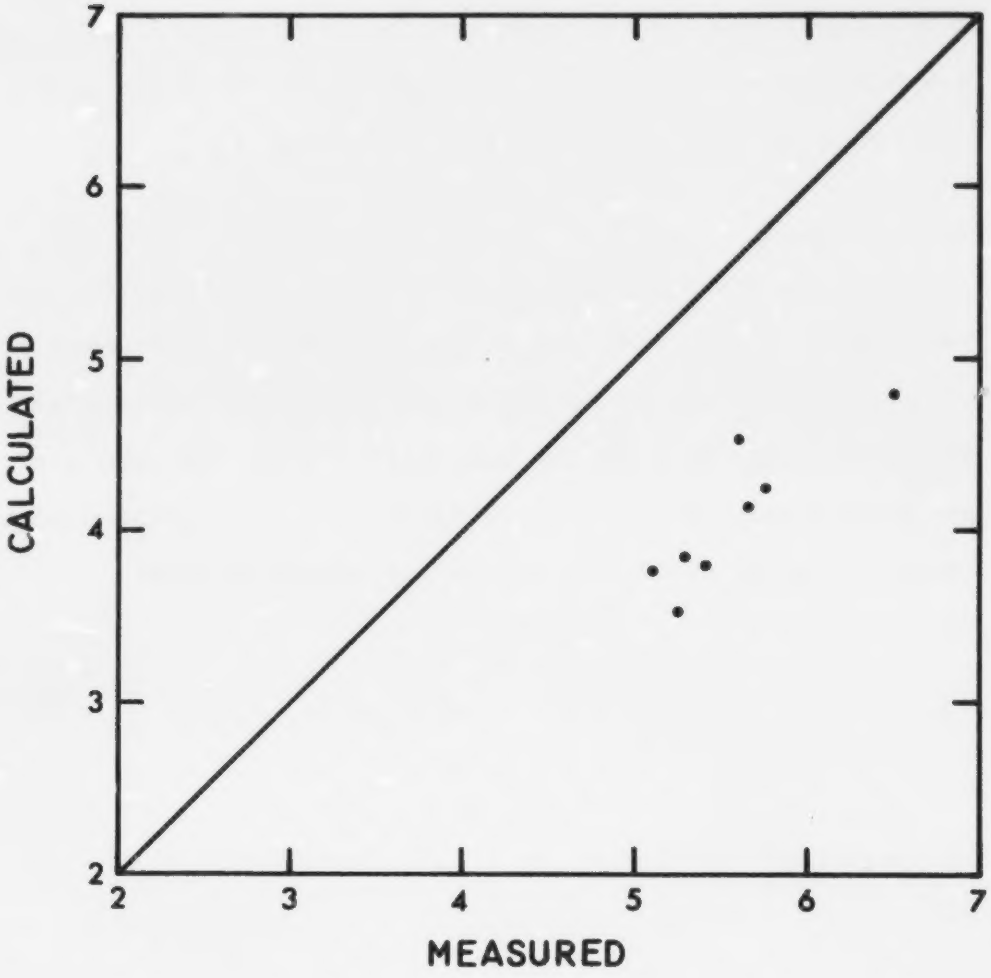

Figure 15.4 Pond 10 Sampler 01, high wind speed experiments x 10^{-6} g moles/m^3

```
          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
 DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

 POND LOCATION CODE 10   SAMPLER NUMBER 01

 DATE  6/16/73   START TIME  10:27 A.M.
 SAMPLING LENGTH 60.0 MIN.


 AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.1860
 SKY CONDITION   High overcast - sun casting light shadow

 TIME AVERAGE WIND DIRECTION AT 3.05 METERS   19.66 DEGREES
 TIME AVERAGE WIND SPEED AT 3.05 METERS   5.8 M/SEC
 AIR TEMPERATURE    83.0F DRY BULB   73.5F WET BULB


 POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

 SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
    1               89.8               391.0E-06
    2               91.0               403.0E-06
    3               92.7               429.0E-06
    4               95.8               495.0E-06
    5               99.5               630.0E-06
    6              104.0               815.0E-06
    7              106.7               116.0E-05
    8               88.6               387.0E-06

 MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       5.11500E-06 GRAM_MOLE_F
                   ACTUAL CUBIC METER

 CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       3.73775E-06 GRAM_MOLE_F
                   ACTUAL CUBIC METER
```

```
        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 10    SAMPLER NUMBER 01

DATE  6/16/73    START TIME  11:40 A.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  4    WIND VEL. PROFILE EXP.  0.1820
SKY CONDITION  High overcast

TIME AVERAGE WIND DIRECTION AT 3.05 METERS    16.33 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   6.1 M/SEC
AIR TEMPERATURE   86.5F DRY BULB   75.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1               89.6             391.0E-06
   2               91.0             403.0E-06
   3               92.9             429.0E-06
   4               95.8             495.0E-06
   5               99.5             630.0E-06
   6              104.0             915.0E-06
   7              106.7             116.0E-05
   8               88.6             387.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      5.43200E- 06 GRAM_MOLE_F
                   ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.76698E-06 GRAM_MOLE_F
                   ACTUAL CUBIC METER
```

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        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 10   SAMPLER NUMBER 01

DATE  6/16/73   START TIME  1:31 P.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.1800
SKY CONDITION High overcast - sun shining through slightly

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   12.17 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   6.3 M/SEC
AIR TEMPERATURE   86.0F DRY BULB   73.5F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               91.0               403.0E-06
   2               92.4               420.0E-06
   3               94.3               458.0E-06
   4               97.2               535.0E-06
   5              101.0               710.0E-06
   6              105.6               106.0E-05
   7              108.7               140.0E-05
   8               90.0               392.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      5.75800E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      4.23588E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
```

```
          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 10    SAMPLER NUMBER 01

DATE  6/16/73   START TIME  2:48 P.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.2050
SKY CONDITION  High overcast - short, light shower

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   13.83 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   5.3 M/SEC
AIR TEMPERATURE   82.5F DRY BULB   73.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               91.0                403.0E-06
   2               92.4                420.0E-06
   3               94.3                458.0E-06
   4               97.2                535.0E-06
   5              101.0                710.0E-06
   6              105.6                106.0E-05
   7              108.7                140.0E-05
   8               90.0                392.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      6.50900E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      4.81573E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
```

```
            RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
   DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

   POND LOCATION CODE 10    SAMPLER NUMBER 01

   DATE  6/16/73    START TIME  3:55 P.M.
   SAMPLING LENGTH 60.0 MIN.


   AIR STABILITY CATEGORY  4    WIND VEL. PROFILE EXP.  0.2100
   SKY CONDITION    High overcast

   TIME AVERAGE WIND DIRECTION AT 3.05 METERS   14.66 DEGREES
   TIME AVERAGE WIND SPEED AT 3.05 METERS   4.9 M/SEC
   AIR TEMPERATURE   82.0F DRY BULB   73.0F WET BULB


   POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

   SEGMENT        TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
      1                 91.0               403.0E-06
      2                 92.4               420.0E-06
      3                 94.3               458.0E-06
      4                 97.2               535.0E-06
      5                101.0               710.0E-06
      6                105.6               106.0E-05
      7                108.7               140.0E-05
      8                 90.0               392.0E-06

   MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
         5.64000E-06 GRAM_MOLE_F
                     ACTUAL CUBIC METER

   CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
         4.52193E-06 GRAM_MOLE_F
                     ACTUAL CUBIC METER
```

```
          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10    SAMPLER NUMBER 01

DATE  6/16/73   START TIME  5:00 P.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.1920
SKY CONDITION      High overcast

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   14.66 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   6.1 M/SEC
AIR TEMPERATURE   82.0F DRY BULB   74.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1                91.0             403.0E-06
   2                92.4             420.0E-06
   3                94.3             458.0E-06
   4                97.2             535.0E-06
   5               101.0             710.0E-06
   6               105.6             106.0E-05
   7               108.7             140.0E-05
   8                90.0             392.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      5.67900E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      4.16072E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
```

```
        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 01

DATE  6/22/73   START TIME  11:00 A.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.2030
SKY CONDITION   40 to 60% low cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS    9.67 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   4.7 M/SEC
AIR TEMPERATURE   86.0F DRY BULB   78.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT     TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1              91.6              410.0E-06
   2              93.0              431.0E-06
   3              94.9              470.0E-06
   4              97.2              535.0E-06
   5              99.9              650.0E-06
   6             102.9              830.0E-06
   7             104.8              980.0E-06
   8              90.8              400.0E-06


MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      5.32600E-06 GRAM MOLE F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.84381E-06 GRAM MOLE F
                  ACTUAL CUBIC METER
        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 01

DATE  6/22/73   START TIME  12:07 P.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.1910
SKY CONDITION  60 to 70% low cloud cover; rain shower after 1:07

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   30.50 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   5.2 M/SEC
AIR TEMPERATURE   84.0F DRY BULB   79.5F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT     TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1              91.6              410.0E-06
   2              93.0              431.0E-06
   3              94.9              470.0E-06
   4              97.2              535.0E-06
   5              99.9              650.0E-06
   6             102.9              830.0E-06
   7             104.8              980.0E-06
   8              90.8              400.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      5.22400E-06 GRAM MOLE F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.51175E-06 GRAM MOLE F
                  ACTUAL CUBIC METER
```

15.5.2 Pond 10

Measurements were made when the wind was blowing from the active gypsum pile (wind direction 90° and over). The measured values were considerably greater than the predicted values, Figure 15.5. In this case, the piles caused extremely complex wind patterns - including downwashes that the dispersion model could not handle.

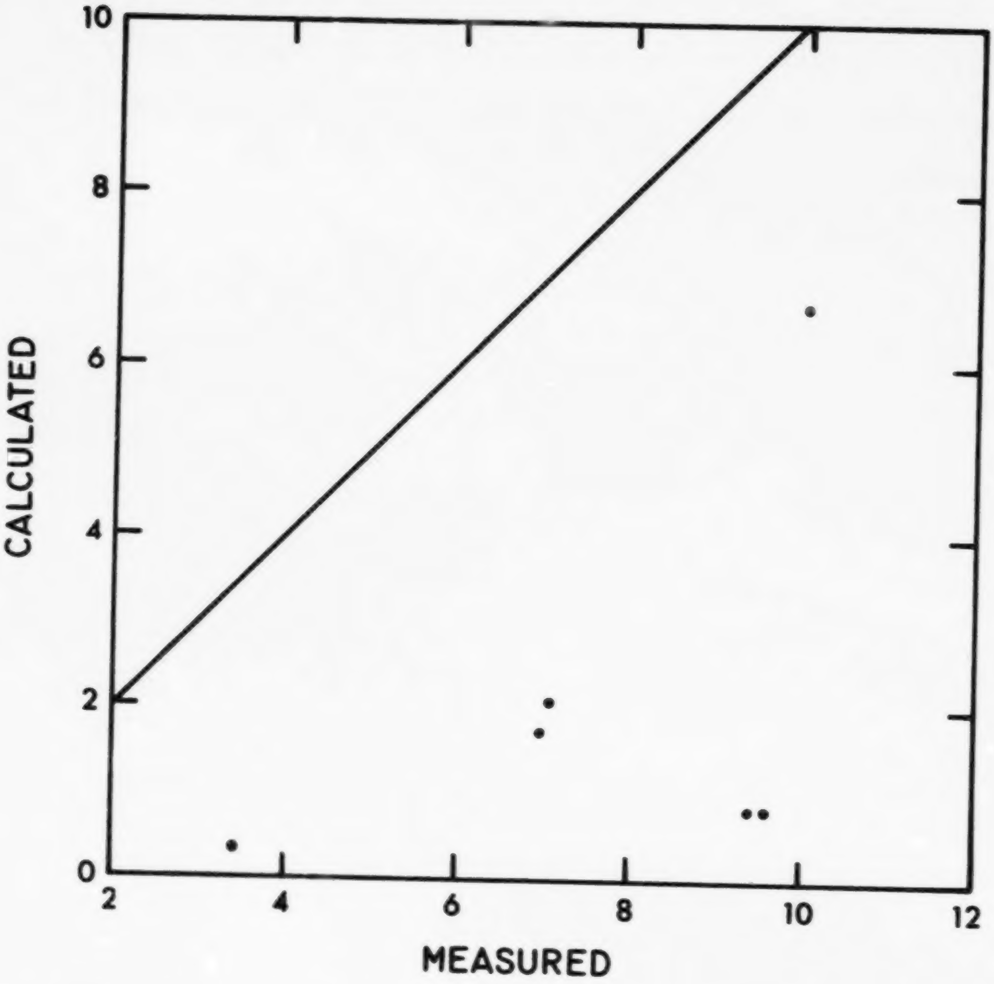

Figure 15.5 Pond 10 wind flow over active gypsum pile x10^{-6} g moles/m^3

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          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 10   SAMPLER NUMBER 01

DATE  6/15/73   START TIME  2:10 P.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  2-3  WIND VEL. PROFILE EXP.  0.2370
SKY CONDITION Clear to 5% cloud cover - light haze

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   54.66 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.1 M/SEC
AIR TEMPERATURE   86.0F DRY BULB   69.5F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               92.5               422.0E-06
   2               93.7               442.0E-06
   3               95.6               487.0E-06
   4               97.8               560.0E-06
   5              100.4               675.0E-06
   6              103.2               845.0E-06
   7              104.8               980.0E-06
   8               91.7               411.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      7.15700E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       2.1365 E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
```

```
           RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
   DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

   POND LOCATION CODE 10    SAMPLER NUMBER 02

   DATE  6/15/73    START TIME  3:00 P.M.
   SAMPLING LENGTH 63.0 MIN.


   AIR STABILITY CATEGORY  2-3  WIND VEL. PROFILE EXP.  0.2290
   SKY CONDITION Clear to 5% cloud cover; slight haze

   TIME AVERAGE WIND DIRECTION AT 3.05 METERS   87.75 DEGREES
   TIME AVERAGE WIND SPEED AT 3.05 METERS   2.6 M/SEC
   AIR TEMPERATURE    86.0F DRY BULB   69.5F WET BULB


   POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

   SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
      1                92.5              422.0E-06
      2                93.7              442.0E-06
      3                95.6              487.0E-06
      4                97.8              560.0E-06
      5               100.4              675.0E-06
      6               103.2              845.0E-06
      7               104.8              980.0E-06
      8                91.7              411.0E-06

   MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
         1.04800E-05 GRAM_MOLE_F
                     ACTUAL CUBIC METER

   CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
         6.6934 E-06   GRAM_MOLE_F
                       ACTUAL CUBIC METER
```

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         RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 01

DATE  6/15/73   START TIME  3:24 P.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY 2-3   WIND VEL. PROFILE EXP.  0.2270
SKY CONDITION 5% cloud cover; slight haze

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   85.49 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.8 M/SEC
AIR TEMPERATURE   88.0F DRY BULB   70.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1                92.5              422.0E-06
   2                93.7              442.0E-06
   3                95.6              487.0E-06
   4                97.8              560.0E-06
   5               100.4              675.0E-06
   6               103.2              845.0E-06
   7               104.8              980.0E-06
   8                91.7              411.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      9.58000E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      8.3933  E-07 GRAM_MOLE_F
                  ACTUAL CUBIC METER
         RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 10   SAMPLER NUMBER 01

DATE  6/15/73   START TIME  4:29 P.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  2-3  WIND VEL. PROFILE EXP.  0.2160
SKY CONDITION 5% cloud cover slight haze

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   64.66 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   3.5 M/SEC
AIR TEMPERATURE   86.0F DRY BULB   69.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT       TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1                92.5              422.0E-06
   2                93.7              442.0E-06
   3                95.6              487.0E-06
   4                97.6              560.0E-06
   5               100.4              675.0E-06
   6               103.2              845.0E-06
   7               104.8              980.0E-06
   8                91.7              411.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      6.51000E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.7788  E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER
```

```
          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 10   SAMPLER NUMBER 01

DATE  6/20/73   START TIME  1:14 P.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  2   WIND VEL. PROFILE EXP.  0.2480
SKY CONDITION 50% cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   82.99 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.1 M/SEC
AIR TEMPERATURE   84.0F DRY BULB   78.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1                92.6              423.0E-06
   2                94.2              450.0E-06
   3                96.6              517.0E-06
   4                99.5              630.0E-06
   5               102.7              815.0E-06
   6               106.5              115.0E-05
   7               108.8              141.0E-05
   8                92.0              417.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      9.36000E-06 GRAM MOLE F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      8.46546E-07 GRAM MOLE F
                  ACTUAL CUBIC METER
          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 1C   SAMPLER NUMBER 01

DATE  6/20/73   START TIME  2:22 P.M.
SAMPLING LENGTH 48.0 MIN.


AIR STABILITY CATEGORY  4   WIND VEL. PROFILE EXP.  0.2070
SKY CONDITION 30 to 100% low cloud cover; 48 minute rain shower
              interrupted experiment
TIME AVERAGE WIND DIRECTION AT 3.05 METERS   92.99 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   4.6 M/SEC
AIR TEMPERATURE   85.0F DRY BULB   79.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               92.6                423.0E-06
   2               94.2                450.0E-06
   3               96.6                517.0E-06
   4               99.5                630.0E-06
   5              102.7                815.0E-06
   6              106.5                115.0E-05
   7              108.8                141.0E-05
   8               92.0                417.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.44700E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.35642E-07 GRAM_MOLE_F
                  ACTUAL CUBIC METER
```

15.5.3 Pond 20

On a number of days after 10:00 A.M., the fluorine concentration measured by sampler 02 increased dramatically as shown in Figure 15.6. No similar increase was noted in sampler 01. Since the phenomena was not noted on the day after a plant shutdown, a tentative explanation is advanced that some action by the plant in the gypsum disposal area caused the high ambient air concentrations.

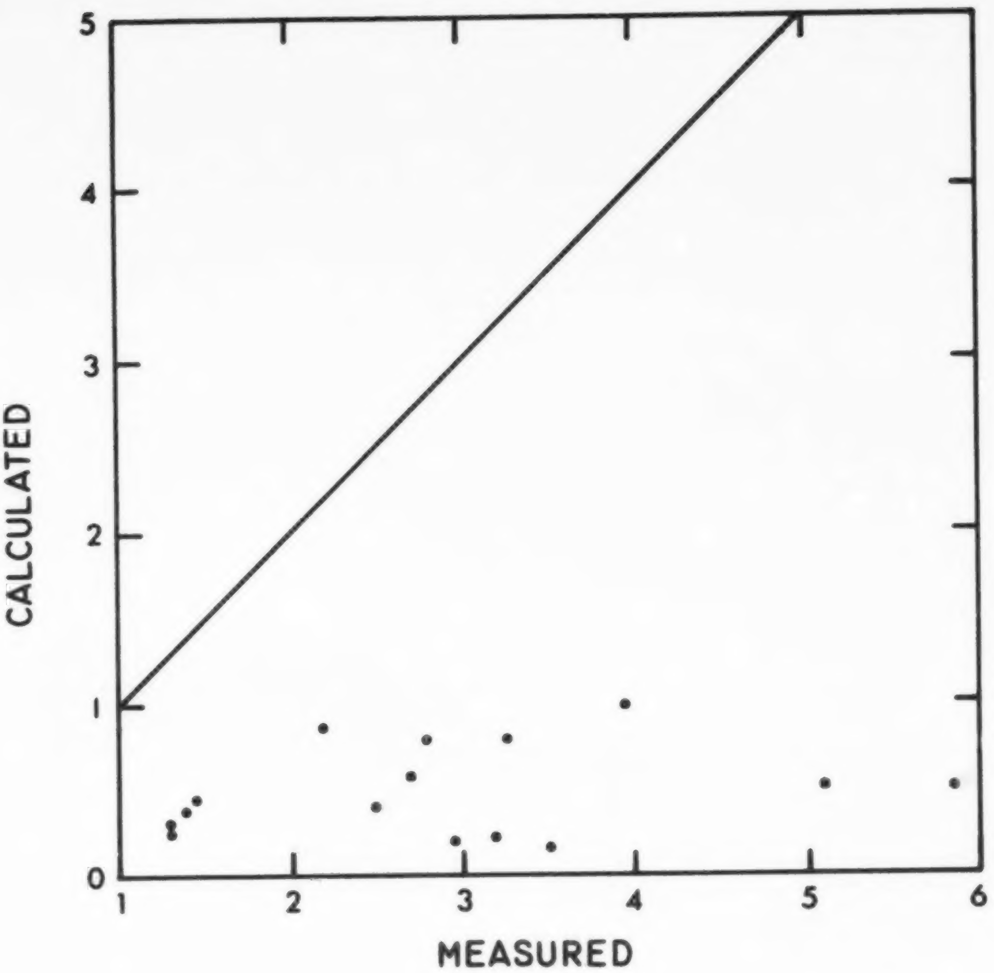

Figure 15.6 Pond 20 Sampler 02 high fluorine measurements x10^{-6} g moles/m^3

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        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 2C    SAMPLER NUMBER 02

DATE  8/17/73    START TIME  11:07 P.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  2   WIND VEL. PROFILE EXP.  0.2300
SKY CONDITION Sunny 30 to 50% mid height cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   83.82 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.6 M/SEC
AIR TEMPERATURE   86.0F DRY BULB   80.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               102.9              568.0E-06
   2               101.5              539.0E-06
   3               100.2              512.0E-06
   4                97.9              475.0E-06
   5                95.7              445.0E-06
   6                93.9              427.0E-06
   7                92.4              410.0E-06
   8                90.7              395.0E-06
   9                90.7              395.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.69100E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      5.86774E-07 GRAM_MOLE_F
                  ACTUAL CUBIC METER
```

```
          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 2C   SAMPLER NUMBER 02

DATE  8/17/73   START TIME  12:17 P.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  2   WIND VEL. PROFILE EXP.  0.2250
SKY CONDITION sunny  50 to 70% mid height cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   77.99 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.9 M/SEC
AIR TEMPERATURE   89.0F DRY BULB   81.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1              104.1              592.0E-06
   2              102.9              568.0E-06
   3              101.7              540.0E-06
   4               99.7              502.0E-06
   5               97.6              471.0E-06
   6               95.9              448.0E-06
   7               94.5              432.0E-06
   8               92.7              414.0E-06
   9               92.7              414.0E-06


MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.83400E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      8.09712E-07 GRAM_MOLE_F
                  ACTUAL CUBIC METER
```

```
           RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 2C   SAMPLER NUMBER 02

DATE  8/17/73   START TIME  1:24 P.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  2   WIND VEL. PROFILE EXP.  0.2310
SKY CONDITION  Sunny  60% mid height cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   77.99 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   3.0 M/SEC
AIR TEMPERATURE    90.0F DRY BULB   81.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               104.1              592.0E-06
   2               102.9              568.0E-06
   3               101.7              540.0E-06
   4                99.7              502.0E-06
   5                97.6              471.0E-06
   6                95.9              448.0E-06
   7                94.5              432.0E-06
   8                92.7              414.0E-06
   9                92.7              414.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.26200E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      9.10783E-07 GRAM_MOLE_F
                  ACTUAL CUBIC METER
```

```
          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 2C    SAMPLER NUMBER 02

DATE  8/17/73    START TIME  2:38 P.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  2   WIND VEL. PROFILE EXP.  0.2310
SKY CONDITION  Sunny    60% cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS    73.32 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   3.0 M/SEC
AIR TEMPERATURE    91.0F DRY BULB   80.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               104.1               592.0E-06
   2               102.9               568.0E-06
   3               101.7               540.0E-06
   4                99.7               502.0E-06
   5                97.6               471.0E-06
   6                95.9               448.0E-06
   7                94.5               432.0E-06
   8                92.7               414.0E-06
   9                92.7               414.0E-06


MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      [illegible].97300E-06 GRAM_MOLE_F
                      ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      9.79836E-07 GRAM_MOLE_F
                      ACTUAL CUBIC METER
```

```
         RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 20   SAMPLER NUMBER 02

DATE  8/18/73   START TIME  9:40 A.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  2   WIND VEL. PROFILE EXP.  0.2240
SKY CONDITION  Sunny  5 to 10% high cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   85.49 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   3.2 M/SEC
AIR TEMPERATURE   84.0F DRY BULB   80.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               99.1               492.0E-06
   2               98.0               478.0E-06
   3               96.9               460.0E-06
   4               95.0               438.0E-06
   5               93.1               420.0E-06
   6               91.6               402.0E-06
   7               89.9               391.0E-06
   8               88.5               385.0E-06
   9               88.5               385.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.44800E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      4.64327E-07 GRAM_MOLE_F
                  ACTUAL CUBIC METER
```

```
          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 2C   SAMPLER NUMBER 02

DATE  8/18/73   START TIME  10:51 A.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  2   WIND VEL. PROFILE EXP.  0.2210
SKY CONDITION   Sunny   10 to 30% mid height cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   96.32 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   3.2 M/SEC
AIR TEMPERATURE    87.0F DRY BULB   80.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1              101.1              530.0E-06
   2               99.0              492.0E-06
   3               97.6              470.0E-06
   4               96.0              459.0E-06
   5               94.1              430.0E-06
   6               92.6              413.0E-06
   7               90.9              398.0E-06
   8               89.5              390.0E-06
   9               89.5              390.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.49600E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.43869E-07 GRAM_MOLE_F
                  ACTUAL CUBIC METER
          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 20    SAMPLER NUMBER 02

DATE   8/18/73    START TIME   11:59 A.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  2    WIND VEL. PROFILE EXP.   0.2260
SKY CONDITION   Sunny   30 to 60% mid height cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS    87.32 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS    2.8 M/SEC
AIR TEMPERATURE    91.0F DRY BULB    80.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT       TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               103.3               575.0E-06
   2               102.1               550.0E-06
   3               101.5               539.0E-06
   4                99.9               508.0E-06
   5                98.0               478.0E-06
   6                96.6               457.0E-06
   7                95.4               442.0E-06
   8                93.9               427.0E-06
   9                93.9               427.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       5.08800E-06 GRAM_MOLE_F
                   ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       5.21512E-07 GRAM_MOLE_F
                   ACTUAL CUBIC METER
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        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 2C    SAMPLER NUMBER 02

DATE  8/18/73    START TIME  1:09 P.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  2-3  WIND VEL. PROFILE EXP.  0.2300
SKY CONDITION Partially sunny; 60% mid height cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS  100.65 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   2.8 M/SEC
AIR TEMPERATURE   91.0F DRY BULB   81.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1              104.3              600.0E-06
   2              103.1              570.0E-06
   3              102.5              560.0E-06
   4              100.9              524.0E-06
   5               99.0              492.0E-06
   6               97.6              470.0E-06
   7               96.4              453.0E-06
   8               94.9              437.0E-06
   9               94.9              437.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      5.84900E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      5.0290   E-07 GRAM_MOLE_F
                  ACTUAL CUBIC METER
        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 02

DATE  8/19/73   START TIME  9:28 A.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  1-2  WIND VEL. PROFILE EXP.  0.2570
SKY CONDITION  Slight haze; 30 to 60% mid height cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   94.99 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.2 M/SEC
AIR TEMPERATURE   83.0F DRY BULB   81.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               97.8                 472.0E-06
   2               96.7                 459.0E-06
   3               95.8                 447.0E-06
   4               94.3                 430.0E-06
   5               92.8                 416.0E-06
   6               91.4                 400.0E-06
   7               90.4                 392.0E-06
   8               89.0                 388.0E-06
   9               89.0                 388.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     1.29900E-06 GRAM MOLE F
                 ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     2.457   E-07 GRAM MOLE F
                 ACTUAL CUBIC METER
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         RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 02

DATE  8/21/73   START TIME  1:53 P.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  1   WIND VEL. PROFILE EXP.  0.2500
SKY CONDITION  60 to 50% mid height cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   72.49 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.2 M/SEC
AIR TEMPERATURE    88.0F DRY BULB   79.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1               96.2              450.0E-06
   2               95.9              448.0E-06
   3               95.5              443.0E-06
   4               94.9              438.0E-06
   5               94.3              430.0E-06
   6               93.6              423.0E-06
   7               93.2              420.0E-06
   8               92.8              417.0E-06
   9               92.8              417.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      7.18200E-07 GRAM MOLE F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      7.75177E-07 GRAM MOLE F
                  ACTUAL CUBIC METER
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        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 02

DATE  8/19/73   START TIME  11:45 A.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  1   WIND VEL. PROFILE EXP.  0.2500
SKY CONDITION  50 to 40% mid height cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   89.99 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.4 M/SEC
AIR TEMPERATURE   88.0F DRY BULB   80.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT     TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1              101.8               543.0E-06
   2              100.7               522.0E-06
   3               99.8               505.0E-06
   4               98.3               480.0E-06
   5               96.8               460.0E-06
   6               95.4               442.0E-06
   7               94.4               430.0E-06
   8               93.0               418.0E-06
   9               93.0               418.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.47500E-06 GRAM MOLE F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      4.19983E-07 GRAM MOLE F
                  ACTUAL CUBIC METER
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         RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 02

DATE  8/19/73   START TIME  12:54 P.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  1   WIND VEL. PROFILE EXP.  0.2460
SKY CONDITION  Sunny  50 to 70% mid height cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS  109.15 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.7 M/SEC
AIR TEMPERATURE   89.0F DRY BULB   81.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1              103.8               588.0E-06
   2              102.7               560.0E-06
   3              101.8               545.0E-06
   4              100.3               515.0E-06
   5               98.8               490.0E-06
   6               97.4               468.0E-06
   7               96.4               452.0E-06
   8               95.0               439.0E-06
   9               95.0               439.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.18500E-06 GRAM_MOLE_F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.17198E-07 GRAM_MOLE_F
                  ACTUAL CUBIC METER
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        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 02

DATE  8/19/73   START TIME  2:10 P.M.
SAMPLING LENGTH 60.C MIN.


AIR STABILITY CATEGORY  F2  WIND VEL. PROFILE EXP.  0.2510
SKY CONDITION  Sunny; 5 min. shower; 70% midheight cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS  117.49 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.3 M/SEC
AIR TEMPERATURE   9C.0F DRY BULB   82.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT       TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1              104.8                 610.0E-06
   2              103.7                 589.0E-06
   3              102.8                 568.0E-06
   4              101.3                 533.0E-06
   5               99.8                 505.0E-06
   6               98.4                 48C.0E-06
   7               97.4                 47C.0E-06
   8               96.0                 450.0E-06
   9               96.0                 45C.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.91200E-06 GRAM MOLE F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       2.2747 E-07 GRAM MOLE F
                   ACTUAL CUBIC METER
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          RUN SUMMARY -- AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 02

DATE  8/20/73   START TIME  11:47 A.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  1   WIND VEL. PROFILE EXP.  0.2450
SKY CONDITION Sunny    40 to 50% mid height cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   94.99 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.4 M/SEC
AIR TEMPERATURE   87.0F DRY BULB   80.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1              92.0                408.0E-06
   2              92.0                408.0E-06
   3              92.0                408.0E-06
   4              92.0                408.0E-06
   5              92.0                408.0E-06
   6              92.0                408.0E-06
   7              92.0                408.0E-06
   8              92.0                408.0E-06
   9              92.0                408.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     9.31400E-07 GRAM MOLE F
                 ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
     2.45667E-07 GRAM MOLE F
                 ACTUAL CUBIC METER
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         RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20    SAMPLER NUMBER 02

DATE  8/20/73    START TIME   12:55 P.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  1   WIND VEL. PROFILE EXP.  0.2480
SKY CONDITION     Sunny  50 to 60% mid height cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS  108.32 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.3 M/SEC
AIR TEMPERATURE    89.0F DRY BULB   79.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT       TEMPERATURE F.DEG      VAPOR PRESSURE MM HG
   1               94.0                 432.0E-06
   2               94.0                 432.0E-06
   3               94.0                 432.0E-06
   4               94.0                 432.0E-06
   5               94.0                 432.0E-06
   6               94.0                 432.0E-06
   7               94.0                 432.0E-06
   8               94.0                 432.0E-06
   9               94.0                 432.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.38900E-06 GRAM MOLE F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      3.87445E-07 GRAM MOLE F
                  ACTUAL CUBIC METER
         RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 20   SAMPLER NUMBER 02

DATE  8/20/73   START TIME  2:04 P.M.
SAMPLING LENGTH 60.C MIN.



AIR STABILITY CATEGORY  1   WIND VEL. PROFILE EXP.  0.2410
SKY CONDITION  60 to 50% mid height cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   95.82 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.7 M/SEC
AIR TEMPERATURE   92.0F DRY BULB   79.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
   1               96.5                457.0E-06
   2               96.5                457.0E-06
   3               96.5                457.0E-06
   4               96.5                457.0E-06
   5               96.5                457.0E-06
   6               96.5                457.0E-06
   7               96.5                457.0E-06
   8               96.5                457.0E-06
   9               96.5                457.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.19200E-06 GRAM MOLE F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      8.75337E-09 GRAM MOLE F
                  ACTUAL CUBIC METER
```

15.5.4 Pond 20

A combination of low wind speeds (less than 1.3 meters/second) and strong solar radiation (late morning and afternoon) produced a greater degree of dispersion than could be predicted by the dispersion model as shown in Figure 15.7. Low wind speeds alone (early and mid-morning) could be satisfactorily handled by the model.

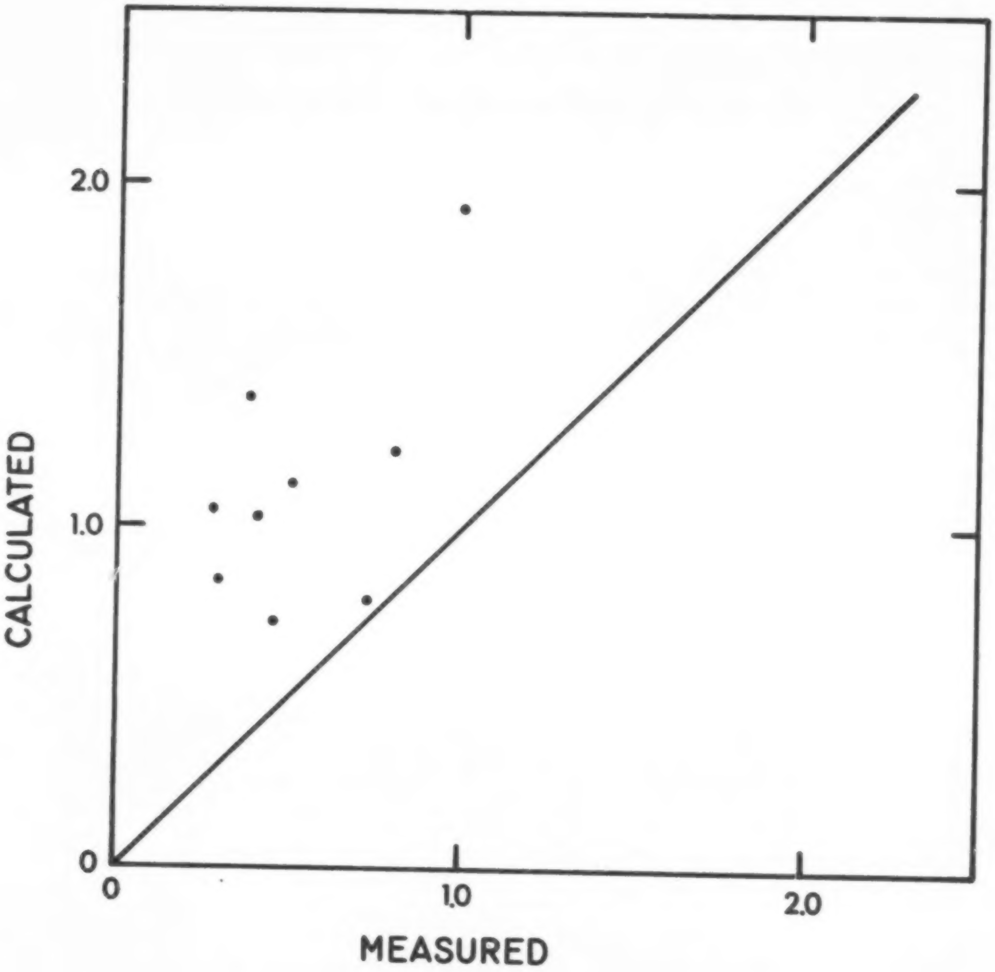

Figure 15.7 Pond 20 strong solar radiation, low wind speed experiments x10^{-6} g moles/m^3

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          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
   DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

   POND LOCATION CODE 20   SAMPLER NUMBER 01

   DATE  8/19/73   START TIME  2:03 P.M.
   SAMPLING LENGTH 60.0 MIN.


   AIR STABILITY CATEGORY  1-2  WIND VEL. PROFILE EXP.  0.2510
   SKY CONDITION  Sunny; 5 min. shower; 70% midheight cloud cover

   TIME AVERAGE WIND DIRECTION AT 3.05 METERS  120.82 DEGREES
   TIME AVERAGE WIND SPEED AT 3.05 METERS   1.3 M/SEC
   AIR TEMPERATURE   90.0F DRY BULB   82.2F WET BULB


   POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

   SEGMENT      TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
      1              104.8                610.0E-06
      2              103.7                582.0E-06
      3              102.8                568.0E-06
      4              101.3                533.0E-06
      5               99.8                505.0E-06
      6               98.4                480.0E-06
      7               97.4                470.0E-06
      8               96.0                450.0E-06
      9               96.0                450.0E-06

  MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
        1.04000E-06 GRAM MOLE F
                    ACTUAL CUBIC METER

  CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
        1.9355  E-06 GRAM MOLE F
                    ACTUAL CUBIC METER
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       RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 20   SAMPLER NUMBER 01

DATE  8/20/73   START TIME  11:42 A.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  1   WIND VEL. PROFILE EXP.  0.2450
SKY CONDITION Sunny; 40 to 50% mid height cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   94.99 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.4 M/SEC
AIR TEMPERATURE   87.0F DRY BULB   80.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1              92.0               408.0E-06
   2              92.0               408.0E-06
   3              92.0               408.0E-06
   4              92.0               408.0E-06
   5              92.0               408.0E-06
   6              92.0               408.0E-06
   7              92.0               408.0E-06
   8              92.0               408.0E-06
   9               0.0               408.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      8.06100E-07 GRAM MOLE F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.23644E-06 GRAM MOLE F
                  ACTUAL CUBIC METER
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          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
 DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

 POND LOCATION CODE 20   SAMPLER NUMBER 01

 DATE  8/20/73   START TIME  12:50 P.M.
 SAMPLING LENGTH 60.0 MIN.


 AIR STABILITY CATEGORY  1   WIND VEL. PROFILE EXP.  0.2480
 SKY CONDITION Sunny; 50 to 60% mid  height cloud cover

 TIME AVERAGE WIND DIRECTION AT 3.05 METERS  108.32 DEGREES
 TIME AVERAGE WIND SPEED AT 3.05 METERS   1.3 M/SEC
 AIR TEMPERATURE   89.0F DRY BULB   79.0F WET BULB


 POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

 SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
    1              94.0                432.0E-06
    2              94.0                432.0E-06
    3              94.0                432.0E-06
    4              94.0                432.0E-06
    5              94.0                432.0E-06
    6              94.0                432.0E-06
    7              94.0                432.0E-06
    8              94.0                432.0E-06
    9              94.0                432.0E-06
                   94.0                432.0E-06

 MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       4.51100E-07 GRAM MOLE F
                   ACTUAL CUBIC METER

 CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
       1.12869E-06 GRAM MOLE F
                   ACTUAL CUBIC METER
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        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 20   SAMPLER NUMBER 01

DATE  8/21/73   START TIME  11:35 A.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  1   WIND VEL. PROFILE EXP.  0.2670
SKY CONDITION  70% mid height cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   35.83 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   0.9 M/SEC
AIR TEMPERATURE   84.0F DRY BULB   79.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1              92.2              410.0E-06
   2              91.9              408.0E-06
   3              91.5              402.0E-06
   4              90.9              400.0E-06
   5              90.3              392.0E-06
   6              89.6              390.0E-06
   7              89.2              389.0E-06
   8              88.8              388.0E-06
   9              88.8              388.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.83800E-07 GRAM MOLE F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.06459E-06 GRAM MOLE F
                  ACTUAL CUBIC METER
        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES


POND LOCATION CODE 20   SAMPLER NUMBER 02

DATE  8/21/73   START TIME  11:35 A.M.
SAMPLING LENGTH 60.0 MIN.



AIR STABILITY CATEGORY  1   WIND VEL. PROFILE EXP.  0.2670
SKY CONDITION    70% midheight cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   35.83 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   0.9 M/SEC
AIR TEMPERATURE   84.0F DRY BULB   79.0F WET BULB



POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT     TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1              92.2               410.0E-06
   2              91.9               408.0E-06
   3              91.5               402.0E-06
   4              90.9               400.0E-06
   5              90.3               392.0E-06
   6              89.6               390.0E-06
   7              89.2               389.0E-06
   8              88.8               388.0E-06
   9              88.8               388.0E-06


MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      4.64900E-07 GRAM MOLE F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      7.28673E-07 GRAM MOLE F
                  ACTUAL CUBIC METER
        RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 01

DATE  8/21/73   START TIME  12:41 P.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  1   WIND VEL. PROFILE EXP.  0.2580
SKY CONDITION    70 to 60% mid height cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   24.16 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.1 M/SEC
AIR TEMPERATURE   84.0F DRY BULB   78.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT     TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1              92.2               410.0E-06
   2              91.9               408.0E-06
   3              91.5               402.0E-06
   4              90.9               400.0E-06
   5              90.3               392.0E-06
   6              89.6               390.0E-06
   7              89.2               389.0E-06
   8              88.8               388.0E-06
   9              88.8               366.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      4.26000E-07 GRAM MOLE F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.03633E-06 GRAM MOLE F
                  ACTUAL CUBIC METER
```

RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 02

DATE 8/21/73   START TIME 12:44 P.M.
SAMPLING LENGTH 60.0 MIN.

AIR STABILITY CATEGORY 1   WIND VEL. PROFILE EXP. 0.2580
SKY CONDITION 70 to 60% mid height cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   24.16 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   1.1 M/SEC
AIR TEMPERATURE   84.0F DRY BULB   78.0F WET BULB

POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT	TEMPERATURE F.DEG	VAPOR PRESSURE MM HG
1	92.2	410.0E-06
2	91.9	408.0E-06
3	91.5	402.0E-06
4	90.9	400.0E-06
5	90.3	392.0E-06
6	89.6	390.0E-06
7	89.2	389.0E-06
8	88.8	388.0E-06
9	88.8	388.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
2.95200E-07 GRAM MOLE F
ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
8.57043E-07 GRAM MOLE F
ACTUAL CUBIC METER

```
                RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
     DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

     POND LOCATION CODE 20   SAMPLER NUMBER 01

     DATE  8/21/73   START TIME  1:49 P.M.
     SAMPLING LENGTH 60.0 MIN.


     AIR STABILITY CATEGORY  1   WIND VEL. PROFILE EXP.  0.2500
     SKY CONDITION  50% mid height cloud cover

     TIME AVERAGE WIND DIRECTION AT 3.05 METERS   72.49 DEGREES
     TIME AVERAGE WIND SPEED AT 3.05 METERS   1.2 M/SEC
     AIR TEMPERATURE   88.OF DRY BULB   79.OF WET BULB


     POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

     SEGMENT      TEMPERATURE F.DEG     VAPOR PRESSURE MM HG
        1              96.2                 450.0E-06
        2              95.9                 448.0E-06
        3              95.5                 443.0E-06
        4              94.9                 438.0E-06
        5              94.3                 430.0E-06
        6              93.6                 423.0E-06
        7              93.2                 420.0E-06
        8              92.8                 417.0E-06
        9              92.8                 417.0E-06

     MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
           3.27400E-07 GRAM MOLE F
                       ACTUAL CUBIC METER

     CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
           1.38254E-06 GRAM MOLE F
                       ACTUAL CUBIC METER
```

```
          RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION
DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLUORIDES

POND LOCATION CODE 20   SAMPLER NUMBER 01

DATE  8/21/73   START TIME  11:35 A.M.
SAMPLING LENGTH 60.0 MIN.


AIR STABILITY CATEGORY  1   WIND VEL. PROFILE EXP.  0.2670
SKY CONDITION  70% mid height cloud cover

TIME AVERAGE WIND DIRECTION AT 3.05 METERS   35.83 DEGREES
TIME AVERAGE WIND SPEED AT 3.05 METERS   0.9 M/SEC
AIR TEMPERATURE   84.0F DRY BULB   79.0F WET BULB


POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROFILE

SEGMENT      TEMPERATURE F.DEG    VAPOR PRESSURE MM HG
   1              92.2               410.0E-06
   2              91.9               408.0E-06
   3              91.5               402.0E-06
   4              90.9               400.0E-06
   5              90.3               392.0E-06
   6              89.6               390.0E-06
   7              89.2               389.0E-06
   8              88.8               388.0E-06
   9              88.8               388.0E-06

MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      2.83800E-07 GRAM MOLE F
                  ACTUAL CUBIC METER

CALCULATED TIME-AVERAGE AMBIENT AIR FLUORIDE CONCENTRATION
      1.06459E-06 GRAM MOLE F
                  ACTUAL CUBIC METER
```

15.6 Sampler Studies

15.6.1 Sampler Efficiency

Since pond water vapor is a mixture of compounds, generation of low, known concentrations is difficult. Therefore, the sampler's efficiency was demonstrated by testing it on an unknown pond-water-fluorine-in-air concentration. Although unknown, sampler recoveries demonstrated that the concentrations were in the range expected in the field work.

An integrated material balance around a sampler yields

$$\log\left(\frac{V_T C_1}{V_T C_2}\right) = K\pi D_T X_T \tag{59}$$

where

C = concentration of fluorine in air:

1 = in 2 = out

D_T = tube diameter

X_T = tube length

K = mass transfer coefficient, and

V_T = volumetric flow rate,

if the fluorine equilibrium partial pressure is assumed to be zero and the total gas volume constant.

If two identical units are connected in series, Equation (59) can be written for each

$$\log \frac{V_T C_1}{V_T C_2} = K\pi\, D_T X_T = \log \frac{V_T C_2}{V_T C_3}\ . \tag{60}$$

If the material collected by each sampler is analyzed separately then the material balances can be written

$$V_TC_1 = V_TC_2 + R_1 \tag{61}$$

$$V_TC_2 = V_TC_3 + R_2 \tag{62}$$

R_i = the amount removed in a sampler .

Equations (60), (61), and (62) contain 3 unknowns and therefore can be solved. After some manipulation (62) can be obtained in terms of R

$$\log \frac{V_TC_1}{V_TC_2} = \log \left(\frac{R_1}{R_2}\right) .$$

Efficiency is usually defined as

$$E = \left(\frac{V_TC_1 - V_TC_2}{V_TC_1}\right) \times 100 = \left(1 - \frac{R_2}{R_1}\right) \times 100 . \tag{63}$$

In a single experiment where two units were connected in series, the measured recoveries were

$R_1 = 5.83 \times 10^{-7}$ g moles fluorine

$R_2 = .82 \times 10^{-7}$ g moles fluorine .

A single unit then has an efficiency of 86%. Using the above efficiency as a basis, the calculated efficiency for two units in series is 98%; three units is 99.7%.

Measurements were made with three units in series. Fluorine was recovered from the first two and the third. The analytical solution to these experiments is not straight forward; however, since little fluorine will get past the third sampler, efficiency can be approximated by

$$E = \left(1 - \frac{R_3}{R_{1+2} + R_3}\right) \times 100$$

R_{1+2} = the amount removed in the first two samplers

R_3 = the amount removed in the third sampler .

The experimental results are tabulated below

X10^{-7} g moles fluorine			
R_{1+2}	R_3	Efficiency	Average Efficiency
3.66	.267	93.2	
10.1	.55	94.8	
5.15	.225	95.8	
6.45	.250	96.3	
			95.0

The 95% average efficiency for two samplers in series is less than predicted but satisfactorily close.

15.6.2 Ambient Air Sampling Procedure

15.6.2.1 Equipment. See Figure 8.4.

15.6.2.2 Procedure.

1) Attach the upper and lower sampling boards to the sampling post. Enter the board numbers on the data sheet.
2) Remove the plugs in the inlet and outlet of the boards.

3) Attach the inlet "y", the outlet tubing (to the rotameter) and the short rubber tube connecting the two sampling boards.

4) Refill the buret with Na_2CO_3 solution and slide it into one leg of the inlet "y".

5) Test the system for leaks by holding the inlet closed, partially closing the bleed valve and observing the rotameter float.

6) Reopen the bleed valve and wet the sampler with 1-2 ml of carbonate solution.

7) Set the air flow rate at 30 liters/minute by partially closing the bleed valve; note and record the starting time.

8) Adjust the carbonate flow rate to 8-12 drops/min.

9) Periodically check the air and carbonate flow rates.

10) Within one minute of the end of the sampling period, flush the sampler with 1 or 2 ml of carbonate solution and shut off the solution flow.

11) At the end of the sampling period, record the end time and open the bleed valve.

12) Remove the carbonate buret, the inlet "y", the outlet tubing and the tubing connecting the two sampling boards.

13) Replace the plugs in the board inlets and outlets.

14) Remove boards from the sampling post and store for later analysis.

15.6.3 Sample Recovery Procedure

1) Remove plugs from the samplers.

2) Connect samplers in series; check the data sheet to make sure that the boards being washed as a set were used as a set.

3) Connect lower sampler to a vacuum pump.

4) Start vacuum pump.

5) Using a graduated cylinder and short stem funnel, wash out the samplers by adding 5-10 ml increments of 1:10 TISAB-Distilled water solution (using a total of 50-75 ml solution.)

6) Draw the solution into the separation flask until the samplers are dry, remove the flask from the system, shake well, pour the solution into an air tight, screw-top, polyethylene sample bottle, and label.

7) Replace flask in system, and repeat procedure with distilled water and acetone; these liquids are discarded. The samplers are now ready for field use.

15.7 Pond Simulation Program

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LEVEL 21.6 ( MAY 72 )                      OS/360  FORTRAN H                              DATE  74.295/16.51.42

          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=58,SIZE=0000K,
                             SOURCE,EBCDIC,NOLIST,DECK,LOAD,MAP,NOEDIT,ID,XREF
                   C      MAIN PROGRAM                              PROGRAMMED BY L. RAINEYF3800060
 ISN 0002                 DIMENSION GA(78),GAA(60),GAB(18),A(100),B(100),C(100),X(100),      F3800070
                         1  Y(100),D(100),DT(100),XW(10),YW(10),DW(10),WS(10),XV(10),YV(10),F3800080
                         2  CTT(10),FNB(10),PV(10),TP(10),ICOR(10),LA(10),LB(10),ITIME(10), F3800090
                         3  INFO(7)                                                          F3800100
 ISN 0003                 EQUIVALENCE(GA(1),GAA(1)),(GA(61),GAB(1))                          F3800110
                   C      GAMMA DISTRIBUTION IN LOOK-UP FORM                                 F3800120
 ISN 0004                 DATA GAA/.0,.0001,.0001,.0002,.0002,.0003,.0005,.0007,.0010,.0013,F3800130
                         1 .0019,.0026,.0035,.0047,.0062,.0082,.0107,.0139,.0179,.0228,      F3800140
                         2 .0287,.0359,.0446,.0548,.0668,.0808,.0968,.1151,.1357,.1587,      F3800150
                         3 .1841,.2119,.2420,.2743,.3085,.3446,.3821,.4207,.4602,.5000,      F3800160
                         4 .5398,.5793,.6179,.6554,.6915,.7257,.7580,.7881,.8159,.8413,      F3800170
                         5 .8643,.8849,.9032,.9192,.9332,.9452,.9554,.9641,.9713,.9772/      F3800180
 ISN 0005                 DATA GAB/.9821,.9861,.9893,.9918,.9938,.9953,.9965,.9974,.9981,    F3800190
                         1 .9987,.9990,.9993,.9995,.9997,.9998,.9998,.9999,.9999/            F3800200
                   C      IR IS READER LOGICAL UNIT NUMBER                                   F3800210
                   C      IW IS PRINTER LOGICAL UNIT NUMBER                                  F3800220
 ISN 0006                 DATA IR,IW/1,3/                                                    F3800230
                   C      FORMATS FOR INPUT                                                  F3800240
 ISN 0007             100 FORMAT(2I5,2F5.0)                                                  F3800250
 ISN 0008             101 FORMAT(5X,I1)                                                      F3800260
 ISN 0009             102 FORMAT(E10.2,4F10.0,I5,F5.0)                                       F3800270
 ISN 0010             103 FORMAT(10F5.0)                                                     F3800280
 ISN 0011             104 FORMAT(10F8.0)                                                     F3800290
 ISN 0012             105 FORMAT(10I2)                                                       F3800300
 ISN 0013             106 FORMAT(A2,A2,5A4)                                                  F3800310
                   C      FORMATS FOR UTILITY OUTPUT                                         F3800320
 ISN 0014             200 FORMAT('1')                                                        F3800330
 ISN 0015             201 FORMAT('0',I4,4X,10E12.5)                                          F3800340
 ISN 0016             202 FORMAT('-AREA',4X,10E12.5)                                         F3800350
 ISN 0017             204 FORMAT('1',T20,'CTOT/FNA  T A B L E'/'-',12X,'T',10(I3,8X,'T'))    F3800360
                   C      FORMATS FOR REPORT OUTPUT                                          F3800370
 ISN 0018             300 FORMAT('1'/'0'/'0'/' '/                                            F3800380
                         +'0',23X,'RUN SUMMARY - AMBIENT AIR FLUORIDE CONCENTRATION'/        F3800390
                         1' ',15X,'DOWN WIND OF PROCESS WATER PONDS CONTAINING DISSOLVED FLU
                         2ORIDES'//'0',15X,'POND LOCATION CODE ',A2,'   SAMPLER NUMBER ',A2/
                         3'0',15X,'DATE ',2A4,'   START TIME ',3A4/' ',15X,'SAMPLING LENGTH F3800420
                         4',F4.1,' MIN.'/'0'/)                                               F3800430
 ISN 0019             301 FORMAT(' ',15X,'AIR STABILITY CATEGORY ',I2,'   WIND VEL. PROFILE
                         +EXP. ',F7.4/' ',15X,'SKY CONDITION '/
                         1'0',15X,'TIME AVERAGE WIND DIRECTION AT 3.05 METERS ',F7.2,' DEGREF3800460
                         2ES'/' ',15X,'TIME AVERAGE WIND SPEED AT 3.05 METERS ',F5.1,' M/SECF3800470
                         3'/' ',15X,'AIR TEMPERATURE  ',F5.1,'F DRY BULB  ',F5.1,'F WET BULBF3800480
                         4')                                                                 F3800490
 ISN 0020             302 FORMAT('0'/'0',15X,'POND TEMPERATURE - FLUORIDE VAPOR PRESSURE PROF3800500
                         +FILE'/'0',15X,'SEGMENT     TEMPERATURE F.DEG    VAPOR PRESSURE MM F3800510
                         1HG'/(' ',15X,I4,13X,0PF5.1,12X,3PE10.1))                           F3800520
 ISN 0021             303 FORMAT('0'/' ',15X,'MEASURED TIME-AVERAGE AMBIENT AIR FLUORIDE CONF3800530
                         +CENTRATION '/21X,1PE12.5,' GRAM MOLE F'/'+',33X,11('_')/' ',33X,'AF3800540
                         1CTUAL CUBIC METER'/'0',15X,'CALCULATED TIME-AVERAGE AMBIENT AIR FLF3800550
                         2UORIDE CONCENTRATION'/21X,E12.5,' GRAM MOLE F'/'+',33X,11('_')/' 'F3800560
                         3,33X,'ACTUAL CUBIC METER')                                         F3800570
 ISN 0022             304 FORMAT('0',120('*')/'0TOO MANY ITERATIONS'/'0',120('*')/)          F3800580
                   C      READ IN NUMBER OF AREAS AND RECEPTOR LOCATION                      F3800590
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```
ISN 0023             READ(IR,100) NIT,NAREA,XREC,YREC                                   F3800600
               C     INITIALIZE LOCATION POINTER                                        F3800610
ISN 0024             II=1                                                               F3800620
               C     LOOP TO READ IN FORMULAS FOR THE LINE SEGMENTS                     F3800630
               C                                                                        F3800640
               C     R E S T R I C T I O N                                              F3800650
               C     AREAS MUST BE FREE OF CONCAVE SIDES                                F3800660
               C     THAT IS ALL INTERIOR ANGLE MUST BE 180 DEGREES OR SMALLER          F3800670
               C     N O T E     MUST BE READ IN CLOCKWISE ORDER                        F3800680
               C                                                                        F3800690
               C                                                                        F3800700
ISN 0025             DO 7 I=1,NAREA                                                     F3800710
               C     READ IN NUMBER OF CORNERS                                          F3800720
ISN 0026             READ(IR,100) J                                                     F3800730
ISN 0027             ICOR(I)=J                                                          F3800740
               C     READ IN FORMULAS OF LINES                                          F3800750
ISN 0028             DO 4 JJ=1,J                                                        F3800760
ISN 0029             READ(IR,103) A(II),B(II),C(II)                                     F3800770
ISN 0030           4 II=II+1                                                            F3800780
ISN 0031           7 CONTINUE                                                           F3800790
               C     LOOP TO CALCULATE X AND Y CORNERS                                  F3800800
               C     USING FORMULAS OF INTERSECTION OF TWO LINES METHOD                 F3800810
               C     CY = A + BX                                                        F3800820
               C     X=C1/C2*A2-A2/C1/C2*B2-B1                                          F3800830
ISN 0032             J=0                                                                F3800840
ISN 0033             DO 1 KNT=1,NAREA                                                   F3800850
ISN 0034             J=J+1                                                              F3800860
ISN 0035             JOLD=J                                                             F3800870
ISN 0036             NCOR=ICOR(KNT)-1                                                   F3800880
ISN 0037             DO 2 I=1,NCOR                                                      F3800890
ISN 0038             JJ=J+1                                                             F3800900
ISN 0039             IF(C(J).EQ.0.)GOTO11                                               F3800910
ISN 0041             RATIO=C(JJ)/C(J)                                                   F3800920
ISN 0042             X(J)=-(RATIO*A(J)-A(JJ))/(RATIO*B(J)-B(JJ))                        F3800930
ISN 0043             Y(J)=(A(J)+B(J)*X(J))/C(J)                                         F3800940
ISN 0044             GOTO12                                                             F3800950
ISN 0045          11 RATIO=C(J)/C(JJ)                                                   F3800960
ISN 0046             X(J)=-(RATIO*A(JJ)-A(J))/(RATIO*B(JJ)-B(J))                        F3800970
ISN 0047             Y(J)=(A(JJ)+B(JJ)*X(J))/C(JJ)                                      F3800980
ISN 0048          12 XD=X(J)-XREC                                                       F3800990
ISN 0049             YD=Y(J)-YREC                                                       F3801000
ISN 0050             D(J)=SQRT(XD*XD+YD*YD)                                             F3801010
ISN 0051             IF(XD.EQ.0.0.AND.YD.GE.0.)OT(J)=1.5708                             F3801020
ISN 0053             IF(XD.EQ.0.0.AND.YD.LT.0.)OT(J)=-1.5708                            F3801030
ISN 0055             IF(XD.NE.0.)OT(J)=ATAN(YD/XD)                                      F3801040
ISN 0057           2 J=J+1                                                              F3801050
               C     NOTE THAT THE LAST AND FIRST LINES ARE NOW USED TO FIND LAST X-Y   F3801060
ISN 0058             JJ=JOLD                                                            F3801070
ISN 0059             IF(C(J).EQ.0.)GOTO13                                               F3801080
ISN 0061             RATIO=C(JJ)/C(J)                                                   F3801090
ISN 0062             X(J)=-(RATIO*A(J)-A(JJ))/(RATIO*B(J)-B(JJ))                        F3801100
ISN 0063             Y(J)=(A(J)+B(J)*X(J))/C(J)                                         F3801110
ISN 0064             GOTO14                                                             F3801120
ISN 0065          13 RATIO=C(J)/C(JJ)                                                   F3801130
ISN 0066             X(J)=-(RATIO*A(JJ)-A(J))/(RATIO*B(JJ)-B(J))                        F3801140
ISN 0067             Y(J)=(A(JJ)+B(JJ)*X(J))/C(JJ)                                      F3801150
```

```
                C     DISTANCE FROM THE RECEPTOR AND ANGLE                                    F3801160
ISN 0068           14 XD=X(J)-XREC                                                            F3801170
ISN 0069              YD=Y(J)-YREC                                                            F3801180
ISN 0070              D(J)=SQRT(XD*XD+YD*YD)                                                  F3801190
ISN 0071              IF(XD.EQ.C.0.AND.YD.GE.0.)OT(J)=1.5708                                  F3801200
ISN 0073              IF(XD.EQ.0.0.AND.YD.LT.0.)OT(J)=-1.5708                                 F3801210
ISN 0075              IF(XD.NE.C.)OT(J)=ATAN(YD/XD)                                           F3801220
ISN 0077            1 CONTINUE                                                                F3801230
                C                                                                             F3801240
                C     COMMON PROGRAM CENTER       IF MORE THAN ONE SET OF DATA                F3801250
                C                                                                             F3801260
                C     READ IN PRINTED OUTPUT CONTROL                                          F3801270
ISN 0078           99 READ(IR,101,END=500)IPR                                                 F3801280
                C     READ IN REPORT VARIABLES                                                F3801290
ISN 0079              READ(IR,106)INFO                                                        F3801300
                C     READ IN POND FLUORIDE VAPOR PRESSURE                                    F3801310
ISN 0080              READ(IR,104)(PV(I),I=1,NAREA)                                           F3801320
                C     READ IN POND WATER TEMPERATURE                                          F3801330
ISN 0081              READ(IR,103)(TP(I),I=1,NAREA)                                           F3801340
                C     READ IN CALCULATED FLUORIDE CONC AND                                    F3801350
                C        WET AND DRY AIR TEMP       H AND Z OF RECEPTOR     AND               F3801360
                C        THE THE STABILITY CLASS    AND LAPSE RATE COEFF                      F3801370
ISN 0082              READ(IR,102)CA,TEMPA,TEMPR,H,Z,KST,XLPS                                 F3801380
                C     READ IN THE NUMBER OF TIME INCREMENTS                                   F3801390
ISN 0083              READ(IR,100) NTIME                                                      F3801400
                C     READ IN LENGTH OF EACH TIME DIVISION                                    F3801410
ISN 0084              READ(IR,105)(ITIME(I),I=1,NTIME)                                        F3801420
                C     READ IN THE WIND SPEED OF EACH TIME DIVISION  MPH                       F3801430
ISN 0085              READ(IR,103)(WS(I),I=1,NTIME)                                           F3801440
                C     READ IN THE WIND DIRECTION OF EACH TIME DIVISION    DEGREES             F3801450
                C     WIND ANGLES OF PLUS OR MINUS 90 DEG. CANNOT BE HANDLED                  F3801460
ISN 0086              READ(IR,103)(OW(I),I=1,NTIME)                                           F3801470
                C     TEST IF CTOT/FNA TABLE IS TO BE PRINTED                                 F3801480
ISN 0087              IF(IPR.EQ.2)WRITE(IW,204)(I,I=1,NTIME)                                  F3801490
                C     CONSTANTS                                                               F3801500
                C     WIND CONSTANT TO CORRECT FROM 3M TO 10M WIND SPEED                      F3801510
ISN 0089              ZHC1=5.2459**XLPS                                                       F3801520
                C     DISPERSION CONSTANT INCLUDING WIND SPEED CORRECTION TO 1.67M            F3801530
ISN 0090              ZHC2=150.398*0.550**XLPS                                                F3801540
ISN 0091              TAWS=0.                                                                 F3801550
ISN 0092              TAWD=0.                                                                 F3801560
ISN 0093              TTIME=0.                                                                F3801570
                C     CALCULATE TIME AVERAGE WIND SPEED AND DIRECTION                         F3801580
                C     AND CONVERT WIND DIRECTION TO RADIANS                                   F3801590
                C     AND WIND SPEED TO METERS / SECOND                                       F3801600
ISN 0094              DO 6 I=1,NTIME                                                          F3801610
ISN 0095              WS(I)=WS(I)*.44702                                                      F3801620
ISN 0096              OW(I)=OW(I)*0.017453                                                    F3801630
ISN 0097              TAWS=TAWS+WS(I)*ITIME(I)                                                F3801640
ISN 0098              TAWD=TAWD+OW(I)*ITIME(I)                                                F3801650
ISN 0099            6 TTIME=TTIME+ITIME(I)                                                    F3801660
ISN 0100              TAWS=TAWS/TTIME                                                         F3801670
ISN 0101              TAWD=(TAWD/TTIME)*57.29                                                 F3801680
                C     SECTIONAL CONSTANTS   (DEPENDENT OF READ IN VALUES)                     F3801690
ISN 0102              PA=CA*(TEMPA+460.)*1.7301E-2                                            F3801700
ISN 0103              ZH1=(Z-H)*(Z-H)                                                         F3801710
ISN 0104          ZH2=(Z+H)*(Z+H)                                                     F3801720
            C     THE MAIN LOOP                                                       F3801730
ISN 0105          J=0                                                                 F3801740
ISN 0106          CTOTF=0.                                                            F3801750
            C     NOTE THAT THE PROGRAM DOES AN AREA FOR ALL TIME SEGMENTS FIRST      F3801760
            C     AREA LOOP                                                           F3801770
ISN 0107          DO 10 KNT=1,NAREA                                                   F3801780
            C     FIND OUT HOW MANY CORNER SEGMENT HAS                                F3801790
ISN 0108          NCOR=ICOR(KNT)                                                      F3801800
ISN 0109          CTOTA=0.                                                            F3801810
            C     TIME LOOP                                                           F3801820
ISN 0110          DO 9 NT=1,NTIME                                                     F3801830
ISN 0111          CTOT=0.                                                             F3801840
            C     SET WIND SPEED                                                      F3801850
ISN 0112          WSNOW=WS(NT)                                                        F3801860
            C     FKG IS MASS TRANSFER COEFFICIENT                                    F3801870
ISN 0113          FKG=8.0667E-3*(WSNOW*ZHC1)**.8                                      F3801880
            C     FNA IS EMISSION RATE PER UNIT AREA                                  F3801890
ISN 0114          FNA=FKG*(PV(KNT)-PA)                                                F3801900
            C     SAVE FNA FOR LATER PRINTOUT                                         F3801910
ISN 0115          FNB(NT)=FNA                                                         F3801920
            C     SET WIND DIRECTION                                                  F3801930
ISN 0116          OWIND=OW(NT)                                                        F3801940
ISN 0117          SINOW=SIN(OWIND)                                                    F3801950
ISN 0118          COSOW=COS(OWIND)                                                    F3801960
            C     FIND DISTANCE OF AREA CORNER FROM RECEPTOR WRT WINDLINE             F3801970
ISN 0119          BW=SINOW/COSOW                                                      F3801980
ISN 0120          CK=-BW                                                              F3801990
ISN 0121          AW=YREC-BW*XREC                                                     F3802000
ISN 0122          DO 8 I=1,NCOR                                                       F3802010
ISN 0123          K=J+I                                                               F3802020
            C     CORNER PROJECTED ONTO THE WINDLINE                                  F3802030
ISN 0124          AK=CK*Y(K)-X(K)                                                     F3802040
ISN 0125          XW(I)=-(CK*AW-AK)/(CK*BW-1)                                         F3802050
ISN 0126          YW(I)=AW+BW*XW(I)                                                   F3802060
            C     COPY MADE FOR COUNTER CLOCKWISE TRAVERSAL                           F3802070
ISN 0127          XV(I)=XW(I)                                                         F3802080
ISN 0128        8 YV(I)=YW(I)                                                         F3802090
            C     SORT CORNER ROUTINE FOR MAX AND MIN CORNER DISTANCE FROM RECEPTOR F3802100
ISN 0129          XMAX=-9.E50                                                         F3802110
ISN 0130          XMIN=9.E50                                                          F3802120
ISN 0131          DO 16 I=1,NCOR                                                      F3802130
ISN 0132          XRD=XW(I)-XREC                                                      F3802140
ISN 0133          IF(XRD.GT.XMIN) GOTO15                                              F3802150
ISN 0135          XMIN=XRD                                                            F3802160
ISN 0136          IMIN=I                                                              F3802170
ISN 0137       15 IF(XRD.LT.XMAX) GOTO16                                              F3802180
ISN 0139          XMAX=XRD                                                            F3802190
ISN 0140          JMAX=I                                                              F3802200
ISN 0141       16 CONTINUE                                                            F3802210
            C     CHECK IF IN QUADRENT 2 OR 3 IF SO REVERSE MAX AND MIN               F3802220
ISN 0142          IF(XMAX.GT.XREC)GO TO 17                                            F3802230
ISN 0144          KMAX=IMIN                                                           F3802240
ISN 0145          IMIN=JMAX                                                           F3802250
ISN 0146          JMAX=KMAX                                                           F3802260
ISN 0147          KFLAG=-1                                                            F3802270
ISN 0148          GO TO 18                                                      F3802280
ISN 0149       17 KFLAG=1                                                       F3802290
ISN 0150       18 IMAX=JMAX-1                                                   F3802300
            C     ORDER CORNERS IN ORDER OF USE                                 F3802310
            C    FOR CLOCKWISE PATH  MAX TO MIN CORNERS                         F3802320
ISN 0151          IMAX=JMAX-1                                                   F3802330
ISN 0152          DO 80 I=1,NCOR                                                F3802340
ISN 0153          IMAX=IMAX+1                                                   F3802350
ISN 0154          IF(IMAX.GT.NCOR)IMAX=1                                        F3802360
ISN 0156          LA(I)=IMAX                                                    F3802370
ISN 0157          IF(IMAX.EQ.IMIN) GOTO81                                       F3802380
ISN 0159       80 CONTINUE                                                      F3802390
            C     ORDER CORNERS IN ORDER OF USE                                 F3802400
            C     FOR COUNTER CLOCKWISE PATH FROM MAX TO MIN CORNER             F3802410
ISN 0160       81 IMAX=JMAX+1                                                   F3802420
ISN 0161          DO 82 I=1,NCOR                                                F3802430
ISN 0162          IMAX=IMAX-1                                                   F3802440
ISN 0163          IF(IMAX.LT.1)IMAX=NCOR                                        F3802450
ISN 0165          LB(I)=IMAX                                                    F3802460
ISN 0166          IF(IMAX.EQ.IMIN) GOTO83                                       F3802470
ISN 0168       82 CONTINUE                                                      F3802480
            C     LA IS LINE ORDER MAX TO MIN   CLOCKWISE                       F3802490
            C     LB IS LINE ORDER MAX TO MIN   COUNTERCLOCKWISE                F3802500
            C     II IS MOST MAX  JJ IS NEXT CORNER    CLOCKWISE                F3802510
            C     LL IS MOST MAX  MM IS NEXT CORNER    COUNTER CLOCKWISE        F3802520
ISN 0169       83 II=LA(1)                                                      F3802530
ISN 0170          JJ=LA(2)                                                      F3802540
ISN 0171          LL=LB(1)                                                      F3802550
ISN 0172          MM=LB(2)                                                      F3802560
ISN 0173          KA=3                                                          F3802570
ISN 0174          KB=3                                                          F3802580
ISN 0175          JIT=NIT                                                       F3802590
ISN 0176          JFLAG=1                                                       F3802600
            C     INCREMENT ALONG WINDLINE WRT CORNERS                          F3802610
ISN 0177          IF(OWIND.GE.0.AND.OWIND.LE.1.5708)GO TO 23
ISN 0179          IF(OWIND.LE.0.AND.OWIND.GE.-1.5708)GO TO 23
ISN 0181          COSOW=-COSOW
ISN 0182          SINOW=-SINOW
ISN 0183       23 XWI=XW(II)-10.*COSOW*KFLAG                                    F3802620
ISN 0184          YWI=YW(II)-10.*SINOW*KFLAG                                    F3802630
ISN 0185          JIT=JIT-1                                                     F3802640
ISN 0186          IF(JIT.EQ.0)GOTO98                                            F3802650
ISN 0188          DEL=5.                                                        F3802660
ISN 0189          IFLAG=0                                                       F3802670
ISN 0190          IF(KFLAG*(XWI-XW(JJ)).GE.0.)GO TO 21                          F3802680
            C     WE PASSED A CORNER CLOCKWISE SO USE CORNER INSTEAD            F3802690
ISN 0192          DEL=ABS((XW(II)-XW(JJ))/(2.*COSOW))                           F3802700
ISN 0193          XWI=XW(JJ)                                                    F3802710
ISN 0194          YWI=YW(JJ)                                                    F3802720
ISN 0195          IFLAG=1                                                       F3802730
ISN 0196       21 XVI=XV(LL)-10.*COSOW*KFLAG                                    F3802740
ISN 0197          YVI=YV(LL)-10.*SINOW*KFLAG                                    F3802750
ISN 0198          IF(KFLAG*(XVI-XV(MM)).GE.0.)GO TO 24                          F3802760
            C     WE PASSED A CORNER COUNTERCLOCKWISE SO USE CORNER INSTEAD     F3802770
ISN 0200          DELB=ABS((XV(LL)-XV(MM))/(2.*COSOW))                          F3802780
            C     TEST CORNERS TO SEE WHICH IS MOST MAX AND USE ITS DEL         F3802790
```

```
ISN 0201        IF(DELB.GE.DEL) GOTO24                                            F3802800
ISN 0203        DEL=DELB                                                          F3802810
ISN 0204        XWI=XVI                                                           F3802820
ISN 0205        YWI=YVI                                                           F3802830
ISN 0206        IFLAG=2                                                           F3802840
          C     IFLAG PURPOSE                                                     F3802850
          C     0 = NO CORNER OVER RUN                                            F3802860
          C     1 = WE USED CORNER CLOCKWISE                                      F3802870
          C     2 = WE USED CORNER COUNTER CLOCKWISE                              F3802880
ISN 0207     24 IF(IFLAG.EQ.1)GOTO22                                              F3802890
ISN 0209        XW(II)=XWI                                                        F3802900
ISN 0210        YW(II)=YWI                                                        F3802910
ISN 0211     22 XV(LL)=XWI                                                        F3802920
ISN 0212        YV(LL)=YWI                                                        F3802930
          C        MIDPOINT OF AREA SEGMENT AT WINDLINE                           F3802940
ISN 0213        XWBAR=XWI+DEL*COSOW*KFLAG                                         F3802950
ISN 0214        YWBAR=YWI+DEL*SINOW*KFLAG                                         F3802960
ISN 0215        IF(UWIND.GE.0.AND.OWIND.LE.1.5708.AND.XWBAR.GE.XREC.AND.YWBAR.GE.YF3802970
               1REC)GO TO 30                                                      F3802980
ISN 0217        IF(OWIND.GE.1.5708.AND.OWIND.LE.3.14159.AND.XWBAR.LE.XREC.AND.YWBAF3802990
               1R.GE.YREC)GO TO 30                                                F3803000
ISN 0219         IF(OWIND.LE.0.AND.OWIND.GE.-1.5708.AND.XWBAR.GE.XREC.AND.YWBAR.LEF3803010
               1.YREC)GO TO 30                                                    F3803020
ISN 0221        IF(OWIND.LE.-1.5708.AND.OWIND.GE.-3.14159.AND.XWBAR.LE.XREC.AND.YWF3803030
               1BAR.LE.YREC)GO TO 30                                              F3803040
ISN 0223        GO TO 47                                                          F3803050
ISN 0224     30 XD=XWBAR-XREC                                                     F3803060
ISN 0225        YD=YWBAR-YREC                                                     F3803070
          C     DISTANCE BETWEEN SOURCE AREA AND RECEPTOR                         F3803080
ISN 0226        DBAR=SQRT(XD*XD+YD*YD)                                            F3803090
          C     CALCULATE Y LIMITS OF THE AREA                                    F3803100
ISN 0227        BC=-1./BW                                                         F3803110
ISN 0228        AC=YWBAR-BC*XWBAR                                                 F3803120
ISN 0229        KK=J+JJ                                                           F3803130
ISN 0230        XI=-(C(KK)*AC-A(KK))/(C(KK)*BC-B(KK))                             F3803140
ISN 0231        YI=AC+BC*XI                                                       F3803150
ISN 0232        KK=J+LL                                                           F3803160
ISN 0233        XJ=-(C(KK)*AC-A(KK))/(C(KK)*BC-B(KK))                             F3803170
ISN 0234        YJ=AC+BC*XJ                                                       F3803180
ISN 0235        Y1P=SQRT((XWBAR-XI)*(XWBAR-XI)+(YWBAR-YI)*(YWBAR-YI))             F3803190
ISN 0236        Y2P=SQRT((XWBAR-XJ)*(XWBAR-XJ)+(YWBAR-YJ)*(YWBAR-YJ))             F3803200
ISN 0237        IF(YWBAR-YI.LT.0.)Y1P=-Y1P                                        F3803210
ISN 0239        IF(YWBAR-YJ.LT.0.)Y2P=-Y2P                                        F3803220
          C     METERS TO KILOMETERS                                              F3803230
ISN 0241        XT=DBAR*.001                                                      F3803240
ISN 0242        XY=DBAR*.001                                                      F3803250
          C     CALCULATE HORI AND VERT STD. DEV (OF 1972 VER OF DBTSYZ)          F3803260
ISN 0243        CALL DBTSYZ(XT,XY,KST,SY,SZ)                                      F3803270
          C     DETERMIN GAMMA DISTIBUTION HORIZONTAL OF CONC BETWEEN Y LIMITS OF AREA
ISN 0244        SMAX=Y1P/SY                                                       F3803280
ISN 0245        SMIN=Y2P/SY                                                       F3803290
ISN 0246        IF(SMAX.GE.3.8) GOTO31                                            F3803300
ISN 0248        IF(SMAX.LE.-3.8)GOTO32                                            F3803310
ISN 0250        SSD = SMAX*10.+40.                                                F3803320
ISN 0251        ISD = SSD                                                         F3803330
ISN 0252        SSD = ISD                                                         F3803340
ISN 0253          CFMAX = GA(ISD)+(SSD-SSO)*(GA(ISD+1)-GA(ISD))                       F3803350
ISN 0254          GOTO33                                                               F3803360
ISN 0255       31 CFMAX=1.0                                                            F3803370
ISN 0256          GOTU33                                                               F3803380
ISN 0257       32 CFMAX=0.                                                             F3803390
ISN 0258       33 IF(SMIN.GE.3.8)GOTO34                                                F3803400
ISN 0260          IF(SMIN.LE.-3.8) GOTO35                                              F3803410
ISN 0262          SSD = SMIN*10.+40.                                                   F3803420
ISN 0263          ISD = SSD                                                            F3803430
ISN 0264          SSO = ISD                                                            F3803440
ISN 0265          CFMIN = GA(ISD)+(SSD-SSO)*(GA(ISD+1)-GA(ISD))                       F3803450
ISN 0266          GOTO36                                                               F3803460
ISN 0267       34 CFMIN=1.0                                                            F3803470
ISN 0268          GOTO36                                                               F3803480
ISN 0269       35 CFMIN=0.                                                             F3803490
             C    DETERMINE GAMMA DISTIBUTION VERTICLE OF CONC BETWEEN Y LIMITS OF AREA
ISN 0270       36 CFM=ABS(CFMAX-CFMIN)                                                 F3803500
ISN 0271          C2 =2.*SZ*SZ                                                         F3803510
ISN 0272          C3=ZH1/C2                                                            F3803520
ISN 0273          C4=ZH2/C2                                                            F3803530
ISN 0274          IF(C3.LT.0.005) GOTO41                                               F3803540
ISN 0276          IF(C3.GE.50.) GOTO42                                                 F3803550
ISN 0278          C3P=1./EXP(C3)                                                       F3803560
ISN 0279          GOTO43                                                               F3803570
ISN 0280       41 C3P=1.0                                                              F3803580
ISN 0281          GOTO43                                                               F3803590
ISN 0282       42 C3P=0.0                                                              F3803600
ISN 0283       43 IF(C4.LT.0.005) GOTO44                                               F3803610
ISN 0285          IF(C4.GE.5C.) GOTO45                                                 F3803620
ISN 0287          C4P=1./EXP(C4)                                                       F3803630
ISN 0288          GOTO46                                                               F3803640
ISN 0289       44 C4P=1.0                                                              F3803650
ISN 0290          GOTO46                                                               F3803660
ISN 0291       45 C4P=0.0                                                              F3803670
             C    CONCENTRATION AT RECEPTOR DUE TO AREA                                F3803680
ISN 0292       46 CWI=(FNA*2.*DEL)/(ZHC2*SZ*WSNOW)                                     F3803690
ISN 0293          CN=CWI*CFM*(C3P+C4P)                                                 F3803700
             C    ACCUMULATED OVER TIME                                                F3803710
ISN 0294          CTOT=CTOT+CN                                                         F3803720
             C    NO CORNER REACHED                                                    F3803730
ISN 0295       47 IF(IFLAG.EQ.0)GO TO 23                                               F3803740
             C    CLOCKWISE CORNER REACHED                                             F3803750
ISN 0297          IF(JFLAG.EQ.0) GOTO19                                                F3803760
             C    COUNTER-CLOCKWISE CORNER REACHED                                     F3803770
ISN 0299          IF(IFLAG.EQ.2)GOTO25                                                 F3803780
             C    CHANGE CLOCKWISE CORNER BY ONE                                       F3803790
ISN 0301          II=JJ                                                                F3803800
ISN 0302          JJ=LA(KA)                                                            F3803810
ISN 0303          KA=KA+1                                                              F3803820
ISN 0304          GOTO20                                                               F3803830
             C    CHANGE COUNTER-CLOCKWISE CORNER BY ONE                               F3803840
ISN 0305       25 LL=MM                                                                F3803850
ISN 0306          MM=LB(KB)                                                            F3803860
ISN 0307          KB=KB+1                                                              F3803870
             C    JFLAS  = C   CORNER IS NEAREST TO RECEPTOR                           F3803880
ISN 0308       20 IF(JJ.EQ.MM) JFLAG=0                                                 F3803890
ISN 0310           GOTO23                                                          F3803900
              C    SET CTOT TO ZERO IF WIND IS NOT BLOWING FROM RIGHT DIRECTION    F3803910
ISN 0311        98 WRITE(IW,304)                                                   F3803920
ISN 0312        26 CTOT=0.0                                                        F3803930
ISN 0313        19 CONTINUE                                                        F3803940
              C     INFO CONVERSION FOR FINAL REPORT                               F3803950
ISN 0314           CTT(NT)=CTOT                                                    F3803960
ISN 0315           ATIME=ITIME(NT)                                                 F3803970
ISN 0316           CTOTA=CTOTA+CTOT*ATIME                                          F3803980
ISN 0317         9 CONTINUE                                                        F3803990
ISN 0318           CTOTF=CTOTF+CTOTA/TTIME                                         F3804000
              C    PRINT FINAL REPORT                                              F3804010
ISN 0319           IF(IPR.EQ.1)GOTO10                                              F3804020
ISN 0321           WRITE(IW,202)(CTT(JJ),JJ=1,NTIME)                               F3804030
ISN 0322           WRITE(IW,201)KNT,(FNB(JJ),JJ=1,NTIME)                           F3804040
ISN 0323        10 J=J+NCOR                                                        F3804050
ISN 0324           WRITE(IW,300)INFO,TTIME                                         F3804060
ISN 0325           WRITE(IW,301)KST,XLPS,TAWD,TAWS,TEMPA,TEMPB                     F3804070
ISN 0326           WRITE(IW,302)(I,TP(I),PV(I),I=1,NAREA)                          F3804080
ISN 0327           WRITE(IW,303)CA,CTOTF                                           F3804090
              C    LOOP FOR NEXT SET OF DATA                                       F3804100
ISN 0328           GO TO 99                                                        F3804110
ISN 0329       500 WRITE(IW,200)                                                   F3804120
ISN 0330           STOP                                                            F3804130
ISN 0331           END                                                             F3804140
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                    *****FORTRAN    CROSS    REFERENCE    LISTING*****                PAGE 009

SYMBOL  INTERNAL STATEMENT NUMBERS
A       0002  0029  0042  0042  0043  0046  0046  0047  0062  0062  0063  0066  0066  0067  0230  0233
B       0002  0029  0042  0042  0043  0046  0046  0047  0062  0062  0063  0066  0066  0067  0230  0233
C       0002  0029  0039  0041  0041  0043  0045  0045  0047  0059  0061  0061  0063  0065  0065  0067  0230  0230  0233
        0233
D       0002  0050  0070
H       0082  0103  0103  0104  0104
I       0025  0027  0037  0080  0080  0080  0081  0081  0081  0084  0084  0084  0085  0085  0085  0086  0086  0086  0087
        0087  0087  0094  0095  0095  0096  0096  0097  0097  0098  0098  0099  0122  0123  0125  0126  0126  0127  0127
        0128  0128  0131  0132  0136  0140  0152  0156  0161  0165  0326  0326  0326  0326  0326
J       0026  0027  0028  0032  0034  0034  0035  0038  0039  0041  0042  0042  0042  0043  0043  0043  0043  0043  0045
        0046  0046  0046  0047  0047  0048  0049  0050  0051  0053  0055  0057  0057  0059  0061  0062  0062  0062  0063
        0063  0063  0063  0063  0065  0066  0066  0066  0067  0067  0068  0069  0070  0071  0073  0075  0105  0123  0229
        0232  0323  0323
K       0123  0124  0124
X       0002  0042  0043  0046  0047  0048  0062  0063  0066  0067  0068  0124
Y       0002  0043  0047  0049  0063  0067  0069  0124
Z       0082  0103  0103  0104  0104
AC      0228  0230  0231  0233  0234
AK      0124  0125
AW      0121  0125  0126
BC      0227  0228  0230  0231  0233  0234
BW      0119  0120  0121  0125  0126  0227
CA      0082  0102  0327
CK      0120  0124  0125  0125
CN      0293  0294
C2      0271  0272  0273
C3      0272  0274  0276  0278
C4      0273  0283  0285  0287
GA      0002  0003  0003  0253  0253  0253  0265  0265  0265
II      0024  0029  0029  0029  0030  0030  0169  0183  0184  0192  0209  0210  0301
IR      0006  0023  0026  0029  0078  0079  0080  0081  0082  0083  0084  0085  0086
IW      0006  0087  0311  0321  0322  0324  0325  0326  0327  0329
JJ      0028  0038  0041  0042  0042  0045  0046  0046  0047  0047  0047  0058  0061  0062  0062  0065  0066  0066  0067
        0067  0067  0170  0190  0192  0193  0194  0229  0301  0302  0308  0321  0321  0321  0322  0322  0322
KA      0173  0302  0303  0303
KB      0174  0306  0307  0307
KK      0229  0230  0230  0230  0230  0232  0233  0233  0233  0233
LA      0002  0156  0169  0170  0302
LB      0002  0165  0171  0172  0306
LL      0171  0196  0197  0200  0211  0212  0232  0305
MM      0172  0198  0200  0305  0306  0308
NT      0110  0112  0115  0116  0314  0315
OT      0002  0051  0053  0055  0071  0073  0075
OW      0002  0086  0096  0096  0098  0116
PA      0102  0114
PV      0002  0080  0114  0326
SY      0243  0244  0245
SZ      0243  0271  0271  0292
TP      0002  0081  0326
WS      0002  0085  0095  0095  0097  0112
XD      0048  0050  0050  0051  0053  0055  0055  0068  0070  0070  0071  0073  0075  0075  0224  0226  0226
XI      0230  0231  0235  0235
XJ      0233  0234  0236  0236
XT      0241  0243
XV      0002  0127  0196  0198  0200  0200  0211
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                                                                                      PAGE 010

                         *****F O R T R A N   C R O S S   R E F E R E N C E   L I S T I N G*****

SYMBOL  INTERNAL STATEMENT NUMBERS
XW      0002  0125  0126  0127  0132  0183  0190  0192  0192  0193  0209
XY      0242  0243
YD      0049  0050  0050  0051  0053  0055  0069  0070  0070  0071  0073  0075  0225  0226  0226
YI      0231  0235  0235  0237
YJ      0234  0236  0236  0239
YV      0002  0128  0197  0212
YW      0002  0126  0128  0184  0194  0210
ABS     0192  0200  0270
CFM     0270  0293
COS     0118
CTT     0002  0314  0321
CWI     0292  0293
C3P     0278  0280  0282  0293
C4P     0287  0289  0291  0293
DEL     0188  0192  0201  0203  0213  0214  0292
EXP     0278  0287
FKG     0113  0114
FNA     0114  0115  0292
FNB     0002  0115  0322
GAA     0002  0003  0004
GAB     0002  0003  0005
IPR     0078  0087  0319
ISD     0251  0252  0253  0253  0253  0263  0264  0265  0265  0265
JIT     0175  0185  0185  0186
KNT     0033  0036  0107  0108  0114  0322
KST     0082  0243  0325
NIT     0023  0175
SIN     0117
SSD     0250  0251  0253  0262  0263  0265
SSO     0252  0253  0264  0265
XRD     0132  0133  0135  0137  0139
XVI     0196  0198  0204
XWI     0183  0190  0193  0204  0209  0211  0213
YVI     0197  0205
YWI     0184  0194  0205  0210  0212  0214
Y1P     0235  0237  0237  0244
Y2P     0236  0239  0239  0245
ZH1     0103  0272
ZH2     0104  0273
ATAN    0055  0075
CTOT    0111  0294  0294  0312  0314  0316
DBAR    0226  0241  0242
DELB    0200  0201  0203
ICOR    0002  0027  0036  0108
IMAX    0150  0151  0153  0153  0154  0154  0156  0157  0160  0162  0162  0163  0163  0165  0166
IMIN    0136  0144  0145  0157  0166
INFO    0002  0079  0324
JMAX    0140  0145  0146  0150  0151  0160
JOLD    0035  0058
KMAX    0144  0146
NCOR    0036  0037  0108  0122  0131  0152  0154  0161  0163  0323
SMAX    0244  0246  0248  0250
SMIN    0245  0258  0260  0262
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                         *****F O R T R A N   C R O S S   R E F F R E N C E   L I S T I N G*****
SYMBOL   INTERNAL STATEMENT NUMBERS
SQRT     0050  0070  0226  0235  0236
TAWD     0092  0098  0098  0101  0101  0325
TAWS     0091  0097  0097  0100  0100  0325
XLPS     0082  0089  0090  0325
XMAX     0129  0137  0139  0142
XMIN     0130  0133  0135
XREC     0023  0048  0068  0121  0132  0142  0215  0217  0219  0221  0224
YREC     0023  0049  0069  0121  0215  0217  0219  0221  0225
ZHC1     0089  0113
ZHC2     0090  0292
ATIME    0315  0316
CFMAX    0253  0255  0257  0270
CFMIN    0265  0267  0269  0270
COSOW    0118  0119  0181  0181  0183  0192  0196  0200  0213
CTOTA    0109  0316  0316  0318
CTOTF    0106  0318  0318  0327
IFLAG    0189  0195  0206  0207  0295  0299
ITIME    0002  0084  0097  0098  0099  0315
JFLAG    0176  0297  0308
KFLAG    0147  0149  0183  0184  0190  0196  0197  0198  0213  0214
NAREA    0023  0025  0033  0080  0081  0107  0326
NTIME    0083  0084  0085  0086  0087  0094  0110  0321  0322
OWIND    0116  0117  0118  0177  0177  0179  0179  0215  0215  0217  0217  0219  0219  0221  0221
RATIO    0041  0042  0042  0045  0046  0046  0061  0062  0062  0065  0066  0066
SINOW    0117  0119  0182  0182  0184  0197  0214
TEMPA    0082  0102  0325
TEMPB    0082  0325
TTIME    0093  0099  0099  0100  0101  0318  0324
WSNOW    0112  0113  0292
XWBAR    0213  0215  0217  0219  0221  0224  0228  0235  0235  0236  0236
YWBAR    0214  0215  0217  0219  0221  0225  0228  0235  0235  0236  0236  0237  0239
OBTSYZ   0243
```

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*****F O R T R A N   C R O S S   R E F E R E N C E   L I S T I N G*****           PAGE 012
LABEL   DEFINED   REFERENCES
   1     0077      0033
   2     0057      0037
   4     0030      0028
   6     0099      0094
   7     0031      0025
   8     0128      0122
   9     0317      0110
  10     0323      0107  0319
  11     0045      0039
  12     0048      0044
  13     0065      0059
  14     0068      0064
  15     0137      0133
  16     0141      0131  0137
  17     0149      0142
  18     0150      0148
  19     0313      0297
  20     0308      0304
  21     0196      0190
  22     0211      0207
  23     0183      0177  0179  0295  0310
  24     0207      0198  0201
  25     0305      0299
  26     0312
  30     0224      0215  0217  0219  0221
  31     0255      0246
  32     0257      0248
  33     0258      0254  0256
  34     0267      0258
  35     0269      0260
  36     0270      0266  0268
  41     0280      0274
  42     0282      0276
  43     0283      0279  0281
  44     0289      0283
  45     0291      0285
  46     0292      0288  0290
  47     0295      0223
  80     0159      0152
  81     0160      0157
  82     0168      0161
  83     0169      0166
  98     0311      0186
  99     0078      0328
 100     0007      0023  0026  0083
 101     0008      0076
 102     0009      0082
 103     0010      0029  0081  0085  0086
 104     0011      0080
 105     0012      0084
 106     0013      0079
 200     0014      0329
 201     0015      0322
 202     0016      0321
 204     0017      0087
```

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                                                                              PAGE 013
                    *****F O R T R A N   C R O S S   R E F E R E N C E   L I S T I N G*****

LABEL   DEFINED   REFERENCES
 300    0018      0324
 301    0019      0325
 302    0020      0326
 303    0021      0327
 304    0022      0311
 500    0329      0078
```

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                                         /    MAIN /     SIZE OF PROGRAM 002A1C HEXADECIMAL BYTES PAGE 014

 NAME     TAG   TYPE  ADD.       NAME     TAG   TYPE  ADD.       NAME     TAG   TYPE  ADD.       NAME     TAG   TYPE  ADD.
      A SF      R*4  00074C         B SF      R*4  0008DC           C SF      R*4  000A6C           D S       R*4  000BFC
      H SF      R*4  0005B8         I SF      I*4  0005BC           J SF      I*4  0005C0           K SF      I*4  0005C4
      X SF      R*4  000D8C         Y SF      R*4  000F1C           Z SF      R*4  0005C8          AC SF      R*4  0005CC
     AK SF      R*4  0005D0        AW SF      R*4  0005D4          BC SF      R*4  0005D8          BW SF      R*4  0005DC
     CA SF      R*4  0005E0        CK SF      R*4  0005E4          CN SF      R*4  0005E8          C2 SF      R*4  0005EC
     C3 SFA     R*4  0005F0        C4 SFA     R*4  0005F4          GA  F    E R*4  001488          II SFA     I*4  0005F8
     IR  F      I*4  0005FC        IW  F      I*4  000600          JJ SFA     I*4  000604          KA SF      I*4  000608
     KB SF      I*4  00060C        KK SF      I*4  000610          LA SF      I*4  0010AC          LB SF      I*4  0010D4
     LL SFA     I*4  000614        MM SFA     I*4  000618          NT SF      I*4  00061C          DT S       R*4  0010FC
     OW SF      R*4  00128C        PA SF      R*4  000620          PV SF      R*4  0012B4          SY SFA     R*4  000624
     SZ SFA     R*4  000628        TP SF      R*4  0012DC          WS SF      R*4  001304          XD SFA     R*4  00062C
     XI SFA     R*4  000630        XJ SFA     R*4  000634          XT SFA     R*4  000638          XV SFA     R*4  00132C
     XW SFA     R*4  001354        XY SFA     R*4  00063C          YD SFA     R*4  000640          YI SFA     R*4  000644
     YJ SFA     R*4  000648        YV SF      R*4  00137C          YW SF      R*4  0013A4         CFM SF      R*4  00064C
    CTT SF      R*4  0013CC       CWI SF      R*4  000650         C3P SF      R*4  000654         C4P SF      R*4  000658
    DEL SF      R*4  00065C       FKG SF      R*4  000660         FNA SF      R*4  000664         FNB SF      R*4  0013F4
    GAA         E R*4  001488       GAB         E R*4  001578         IPR S       I*4  000668         ISO SF      I*4  00066C
    JIT SF      I*4  000670       KNT SF      I*4  000674         KST SFA     I*4  000678         NIT SF      I*4  00067C
    SSD SF      R*4  000680       SSO SF      R*4  000684         XRD SF      R*4  000688         XVI SF      R*4  00068C
    XWI SF      R*4  000690       YVI SF      R*4  000694         YWI SF      R*4  000698         Y1P SF      R*4  00069C
    Y2P SF      R*4  0006A0       ZH1 SF      R*4  0006A4         ZH2 SF      R*4  0006A8        CTOT SF      R*4  0006AC
   DBAR SF      R*4  0006B0      DELB SF      R*4  0006B4        ICOR SF      I*4  00141C        IMAX SF      I*4  0006B8
   IMIN SF      I*4  0006BC      INFO SF      I*4  001444        JMAX SF      I*4  0006C0        JOLD SF      I*4  0006C4
   KMAX SF      I*4  0006C8      NCOR SF      I*4  0006CC        SMAX SF      R*4  0006D0        SMIN SF      R*4  0006D4
   TAWD SF      R*4  0006D8      TAWS SF      R*4  0006DC        XLPS SF      R*4  0006E0        XMAX S       R*4  0006E4
   XMIN S       R*4  0006E8      XREC SF      R*4  0006EC        VREC SF      R*4  0006F0        ZHC1 SF      R*4  0006F4
   ZHC2 SF      R*4  0006F8     ATIME SF      R*4  0006FC       CFMAX SFA     R*4  000700       CFMIN SFA     R*4  000704
  COSOW SFA     R*4  000708     CTOTA SF      R*4  00070C       CTOTF SF      R*4  000710       IFLAG S       I*4  000714
  ITIME SF      I*4  001460     JFLAG S       I*4  000718       KFLAG SF      I*4  00071C       NAREA SF      I*4  000720
  NTIME SF      I*4  000724     OWIND SFA     R*4  000728       RATIO SF      R*4  00072C       SINOW SF      R*4  000730
  TEMPA SF      R*4  000734     TEMPB SF      R*4  000738       TTIME SF      R*4  00073C       WSNOW SF      R*4  000740
  XWBAR SFA     R*4  000744     YWBAR SFA     R*4  000748         EXP        XF R*4  000000         COS        XF R*4  000000
    SIN        XF R*4  000000    FRXPR#        XF R*4  000000        ATAN        XF R*4  000000        SQRT        XF R*4  000000
 DBTSYZ SF     XF R*4  000000    IBCOM#  F     XF I*4  000000
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```
   LABEL   ADDR                LABEL   ADDR                LABEL   ADDR                LABEL   ADDR            PAGE 015

       4   0017EC                  7   0017FC                 11   001882                 12   0018FC
       2   0019A0                 13   001A14                 14   001A60                  1   001B04
      99   001B10                  6   001D98                  8   001F92                 15   001FDE
      16   001FE8                 17   002022                 18   002026                 80   00205A
      81   00205E                 82   002092                 83   002096                 23   00210E
      21   0021E8                 24   002264                 22   00227E                 30   00237C
      31   002576                 32   002582                 33   00258A                 34   00260E
      35   00261C                 36   002624                 41   00269A                 42   0026A8
      43   0026B0                 44   0026F0                 45   0026FE                 46   002706
      47   002744                 25   002788                 20   0027AA                 98   0027C4
      26   0027D8 NR              19   0027E0                  9   002826                 10   00288C
     500   0029D8

*OPTIONS IN EFFECT*      NAME=  MAIN,OPT=02,LINECNT=58,SIZE=0000K,

*OPTIONS IN EFFECT*      SOURCE,EBCDIC,NOLIST,DECK,LOAD,MAP,NOEDIT,ID,XREF

*STATISTICS*     SOURCE STATEMENTS =     330 ,PROGRAM SIZE =    10780

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******
```

```
          COMPILER OPTIONS - NAME=  MAIN,OPT=02,LINECNT=58,SIZE=0000K,
                     SOURCE,EBCDIC,NOLIST,DECK,LOAD,MAP,NOEDIT,ID,XREF
  ISN 0002            SUBROUTINE DBTSYZ (X,XY,KST,SY,SZ)                            F3804150
                C       THIS IS THE 1972 VERSION OF DBTSYZ.                         F3804160
                C       D. B. TURNER, RESEARCH METEOROLOGIST* MODEL DEVELOPMENT BRANCH,F3804170
                C        DIVISION OF METEOROLOGY, ENVIRONMENTAL PROTECTION AGENCY.  F3804180
                C          ROOM 3148, NCHS BUILDING, RTP. PHONE (919) 549-8411 EXT 4564F3804190
                C         MAILING ADDRESS- DM, EPA, RESEARCH TRIANGLE PARK, NC 27711   F3804200
                C        * ON ASSIGNMENT FROM NATIONAL OCEANIC AND ATMOSPHERIC      F3804210
                C              ADMINISTRATION, DEPARTMENT OF COMMERCE.              F3804220
                C       SUBROUTINE DBTSYZ CALCULATES HORIZONTAL AND VERTICAL STANDARD  F3804230
                C        DEVIATIONS OF CONCENTRATION.  THE HORIZONTAL STD. DEV., SY IS F3804240
                C        OBTAINED FROM THE ANGLE BETWEEN A LINE DRAWN FROM THE SOURCE  F3804250
                C        IN THE DOWNWIND DIRECTION AND THE BOUNDARY OF THE PLUME AS IS F3804260
                C        SUGGESTED BY PASQUILL.  PASQUILL'S DISCUSSION ACTUALLY USES   F3804270
                C        TWO TIMES THIS ANGLE.  THE VERTICAL STD. DEV., SZ, IS       F3804280
                C        CALCULATED FROM A SET OF EQUATIONS DEPENDENT UPCN STABILITY   F3804290
                C        CLASS AND DOWNWIND DISTANCE OF THE RECEPTOR.               F3804300
                C       THE VARIABLES USED IN SURROUTINE SIGMA ARE...               F3804310
                C        X     DISTANCE RECEPTOR IS DOWNWIND OF SOURCE (KM)         F3804320
                C        XY    X+VIRTUAL DISTANCE USED FOR AREA SOURCE APPROX. (KM) F3804330
                C        KST   STABILITY CLASS, SEE PAGE 209 OF PASQUILL, ATMOSPHERIC  F3804340
                C                DISPERSION                                          F3804350
                C                 1  IS PASQUILL STABILITY CLASS A                  F3804360
                C                 2  IS PASQUILL STABILITY CLASS B                  F3804370
                C                 3  IS PASQUILL STABILITY CLASS C                  F3804380
                C                 4  IS PASQUILL STABILITY CLASS D2                 F3804390
                C                 5  IS PASQUILL STABILITY CLASS E                  F3804400
                C                 6  IS PASQUILL STABILITY CLASS F                  F3804410
                C                 7  IS PASQUILL STABILITY CLASS D1                 F3804420
                C                41  IS PASQUILL STABILITY CLASS D1                 F3804430
                C                42  IS PASQUILL STABILITY CLASS D2                 F3804440
                C        SY    SIGMA Y, THE STANDARD DEVIATION OF CONCENTRATION IN THE  F3804450
                C              Y-DIRECTION (M)                                      F3804460
                C        SZ    SIGMA Z, THE STANDARD DEVIATION OF CONCENTRATION IN THE  F3804470
                C              Z-DIRECTION (M)                                      F3804480
  ISN 0003            IF (KST-41)2,1,2                                              F3804490
  ISN 0004          1 KST = 7                                                       F3804500
  ISN 0005            GO TO 9                                                       F3804510
  ISN 0006          2 IF (KST-42)9,3,9                                              F3804520
  ISN 0007          3 KST = 4                                                       F3804530
                C         GO TO PROPER SET OF EQUATIONS FOR THIS STABILITY CLASS TO F3804540
                C          CALCULATE TH FOR THE GIVEN XY, AND CALCULATE SZ FOR THE GIVEN F3804550
                C          X.  THEN GO TO 80 WHERE SZ IS LIMITED TO 5000 AND SY IS  F3804560
                C          CALCULATED FROM XY AND TH.  RETURN.                      F3804570
  ISN 0008          9 GO TO (10,30,40,42,52,68,92),KST                              F3804580
                C         STABILITY A (10)                                          F3804590
  ISN 0009         10 TH = (24.167 - 2.5334*ALOG(XY))/57.2958                       F3804600
  ISN 0010            IF(X-0.1)101,102,102                                          F3804610
  ISN 0011        101 SZ = 122.8 * X ** 0.9447                                      F3804620
  ISN 0012            GO TO 80                                                      F3804630
  ISN 0013        102 IF (X-0.15)11,12,12                                           F3804640
  ISN 0014         11 SZ = 158.08 *X ** 1.0542                                      F3804650
  ISN 0015            GO TO 80                                                      F3804660
  ISN 0016         12 IF (X-0.20)13,13,14                                           F3804670
  ISN 0017         13 SZ = 170.22 *X ** 1.0932                                      F3804680
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                                                                                                PAGE 002
ISN 0018            GO TO 80                                                    F3804690
ISN 0019         14 IF (X-0.25)15,15,16                                         F3804700
ISN 0020         15 SZ = 179.52 *X ** 1.1262                                    F3804710
ISN 0021            GO TO 80                                                    F3804720
ISN 0022         16 IF (X-0.30)17,17,18                                         F3804730
ISN 0023         17 SZ = 217.41 *X ** 1.2644                                    F3804740
ISN 0024            GO TO 80                                                    F3804750
ISN 0025         18 IF (X-0.40)19,19,20                                         F3804760
ISN 0026         19 SZ = 258.89 *X ** 1.4094                                    F3804770
ISN 0027            GO TO 80                                                    F3804780
ISN 0028         20 IF (X-0.50)21,21,22                                         F3804790
ISN 0029         21 SZ = 346.75 *X ** 1.7283                                    F3804800
ISN 0030            GO TO 80                                                    F3804810
ISN 0031         22 IF (X-3.11)23,23,24                                         F3804820
ISN 0032         23 SZ = 453.85 *X ** 2.1166                                    F3804830
ISN 0033            GO TO 80                                                    F3804840
ISN 0034         24 SZ = 5000.                                                  F3804850
ISN 0035            GO TO 80                                                    F3804860
               C          STABILITY B (30)                                      F3804870
ISN 0036         30 TH = (18.333 - 1.8096*ALOG(XY))/57.2958                     F3804880
ISN 0037            IF (X-0.2)31,31,32                                          F3804890
ISN 0038         31 SZ = 90.673 *X ** 0.93198                                   F3804900
ISN 0039            GO TO 80                                                    F3804910
ISN 0040         32 IF (X-0.4)33,33,34                                          F3804920
ISN 0041         33 SZ = 98.483 *X ** 0.98332                                   F3804930
ISN 0042            GO TO 80                                                    F3804940
ISN 0043         34 SZ = 109.30 *X ** 1.0971                                    F3804950
ISN 0044            GO TO 80                                                    F3804960
               C          STABILITY C (40)                                      F3804970
ISN 0045         40 TH = (12.5 - 1.0857*ALOG(XY))/57.2958                       F3804980
ISN 0046            SZ = 61.141 *X ** 0.91465                                   F3804990
ISN 0047            GO TO 80                                                    F3805000
               C          STABILITY D2 OR D (42)                                F3805010
ISN 0048         42 TH = (8.3333-0.72382*ALOG(XY))/57.2958                      F3805020
ISN 0049            IF (X-0.3)41,41,39                                          F3805030
ISN 0050         41 SZ = 34.459 *X ** 0.86974                                   F3805040
ISN 0051            GO TO 80                                                    F3805050
ISN 0052         39 IF (X-1.0)43,43,44                                          F3805060
ISN 0053         43 SZ = 32.093 *X ** 0.81066                                   F3805070
ISN 0054            GO TO 80                                                    F3805080
ISN 0055         44 IF (X-3.0)45,45,46                                          F3805090
ISN 0056         45 SZ = 32.093 *X ** 0.64403                                   F3805100
ISN 0057            GO TO 80                                                    F3805110
ISN 0058         46 IF (X-10.)47,47,48                                          F3805120
ISN 0059         47 SZ = 33.504 *X ** 0.60486                                   F3805130
ISN 0060            GO TO 80                                                    F3805140
ISN 0061         48 IF (X-30.)49,49,50                                          F3805150
ISN 0062         49 SZ = 36.650 *X ** 0.56589                                   F3805160
ISN 0063            GO TO 80                                                    F3805170
ISN 0064         50 SZ = 44.053 *X ** 0.51179                                   F3805180
ISN 0065            GO TO 80                                                    F3805190
               C          STABILITY E (52)                                      F3805200
ISN 0066         52 TH = (6.25 - 0.54287*ALOG(XY))/57.2958                      F3805210
ISN 0067            IF (X-0.1)521,522,522                                       F3805220
ISN 0068        521 SZ = 24.26 * X ** 0.8366                                    F3805230
ISN 0069            GO TO 80                                                    F3805240
ISN 0070        522 IF (X-0.3)53,53,54                                                   F3805250
ISN 0071         53 SZ = 23.331 *X ** 0.81956                                            F3805260
ISN 0072            GO TO 80                                                             F3805270
ISN 0073         54 IF (X-1.)55,55,56                                                    F3805280
ISN 0074         55 SZ = 21.628 *X ** 0.75660                                            F3805290
ISN 0075            GO TO 80                                                             F3805300
ISN 0076         56 IF (X-2.)57,57,58                                                    F3805310
ISN 0077         57 SZ = 21.628 *X ** 0.63077                                            F3805320
ISN 0078            GO TO 80                                                             F3805330
ISN 0079         58 IF (X-4.)59,59,60                                                    F3805340
ISN 0080         59 SZ = 22.534 *X ** 0.57154                                            F3805350
ISN 0081            GO TO 80                                                             F3805360
ISN 0082         60 IF (X-10.)61,61,62                                                   F3805370
ISN 0083         61 SZ = 24.703 *X ** 0.50527                                            F3805380
ISN 0084            GO TO 80                                                             F3805390
ISN 0085         62 IF (X-20.)63,63,64                                                   F3805400
ISN 0086         63 SZ = 26.970 *X ** 0.46713                                            F3805410
ISN 0087            GO TO 80                                                             F3805420
ISN 0088         64 IF (X-40.)65,65,66                                                   F3805430
ISN 0089         65 SZ = 35.420 *X ** 0.37615                                            F3805440
ISN 0090            GO TO 80                                                             F3805450
ISN 0091         66 SZ = 47.618 *X ** 0.29592                                            F3805460
ISN 0092            GO TO 80                                                             F3805470
              C           STABILITY F (68)                                               F3805480
ISN 0093         68 TH = (4.1667 - 0.36191*ALOG(XY))/57.2958                             F3805490
ISN 0094            IF (X-0.2)69,69,70                                                   F3805500
ISN 0095         69 SZ = 15.209 *X ** 0.81558                                            F3805510
ISN 0096            GO TO 80                                                             F3805520
ISN 0097         70 IF (X-0.7)73,73,74                                                   F3805530
ISN 0098         73 SZ = 14.457 *X ** 0.78407                                            F3805540
ISN 0099            GO TO 80                                                             F3805550
ISN 0100         74 IF (X-1.)75,75,76                                                    F3805560
ISN 0101         75 SZ = 13.953 *X ** 0.68465                                            F3805570
ISN 0102            GO TO 80                                                             F3805580
ISN 0103         76 IF (X-2.)77,77,78                                                    F3805590
ISN 0104         77 SZ = 13.953 *X ** 0.63227                                            F3805600
ISN 0105            GO TO 80                                                             F3805610
ISN 0106         78 IF (X-3.)79,79,82                                                    F3805620
ISN 0107         79 SZ = 14.823 *X ** 0.54503                                            F3805630
ISN 0108            GO TO 80                                                             F3805640
ISN 0109         82 IF (X-7.)83,83,84                                                    F3805650
ISN 0110         83 SZ = 16.187 *X ** 0.46490                                            F3805660
ISN 0111            GO TO 80                                                             F3805670
ISN 0112         84 IF (X-15.)85,85,86                                                   F3805680
ISN 0113         85 SZ = 17.836 *X ** 0.41507                                            F3805690
ISN 0114            GO TO 80                                                             F3805700
ISN 0115         86 IF (X-30.)87,87,88                                                   F3805710
ISN 0116         87 SZ = 22.651 *X ** 0.32681                                            F3805720
ISN 0117            GO TO 80                                                             F3805730
ISN 0118         88 IF (X-60.)89,89,90                                                   F3805740
ISN 0119         89 SZ = 27.074 *X ** 0.27436                                            F3805750
ISN 0120            GO TO 80                                                             F3805760
ISN 0121         90 SZ = 34.219 *X ** 0.21716                                            F3805770
ISN 0122            GO TO 80                                                             F3805780
              C           STABILITY D1 (92)                                              F3805790
ISN 0123         92 TH = (8.3333 - 0.72392*ALOG(XY))/57.2958                             F3805800
ISN 0124            IF (X-0.3)93,93,94                                    F3805810
ISN 0125         93 SZ = 34.459 *X ** 0.86974                             F3805820
ISN 0126            GO TO 80                                              F3805830
ISN 0127         94 SZ = 32.354 *X ** 0.81738                             F3805840
ISN 0128         80 IF (SZ-5000.)96,96,95                                 F3805850
ISN 0129         95 SZ = 5000.                                            F3805860
ISN 0130         96 SY = 1000.*XY*SIN(TH)/(2.15*COS(TH))                  F3805870
ISN 0131            RETURN                                                F3805880
ISN 0132            END                                                   F3805890
```

```
                          *****F O R T R A N   C R O S S   R E F E R E N C E   L I S T I N G*****                   PAGE 005
SYMBOL   INTERNAL STATEMENT NUMBERS
X        0002  0010  0011  0013  0014  0016  0017  0019  0020  0022  0023  0025  0026  0028  0029  0031  0032  0037  0038
         0040  0041  0043  0046  0049  0050  0052  0053  0055  0056  0058  0059  0061  0062  0064  0067  0068  0070  0071
         0073  0074  0076  0077  0079  0080  0082  0083  0085  0086  0088  0089  0091  0094  0095  0097  0098  0100  0101
         0103  0104  0106  0107  0109  0110  0112  0113  0115  0116  0118  0119  0121  0124  0125  0127
SY       0002  0130
SZ       0002  0011  0014  0017  0020  0023  0026  0029  0032  0034  0038  0041  0043  0046  0050  0053  0056  0059  0062
         0064  0068  0071  0074  0077  0080  0083  0086  0089  0091  0095  0098  0101  0104  0107  0110  0113  0116  0119
         0121  0125  0127  0128  0129
TH       0009  0036  0045  0048  0066  0093  0123  0130  0130
XY       0002  0009  0036  0045  0048  0066  0093  0123  0130
COS      0130
KST      0002  0003  0004  0006  0007  0008
SIN      0130
ALOG     0009  0036  0045  0048  0066  0093  0123
DBTSYZ   0002
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                 *****F O R T R A N   C R O S S   R E F E R E N C E   L I S T I N G*****           PAGE 006
LABEL   DEFINED   REFERENCES
   1    0004      0003
   2    0006      0003  0003
   3    0007      0006
   9    0008      0005  0006  0006
  10    0009      0008
  11    0014      0013
  12    0016      0013  0013
  13    0017      0016  0016
  14    0019      0016
  15    0020      0019  0019
  16    0022      0019
  17    0023      0022  0022
  18    0025      0022
  19    0026      0025  0025
  20    0028      0025
  21    0029      0028  0028
  22    0031      0028
  23    0032      0031  0031
  24    0034      0031
  30    0036      0008
  31    0038      0037  0037
  32    0040      0037
  33    0041      0040  0040
  34    0043      0040
  39    0052      0049
  40    0045      0008
  41    0050      0049  0049
  42    0048      0008
  43    0053      0052  0052
  44    0055      0052
  45    0056      0055  0055
  46    0058      0055
  47    0059      0058  0058
  48    0061      0058
  49    0062      0061  0061
  50    0064      0061
  52    0066      0008
  53    0071      0070  0070
  54    0073      0070
  55    0074      0073  0073
  56    0076      0073
  57    0077      0076  0076
  58    0079      0076
  59    0080      0079  0079
  60    0082      0079
  61    0083      0082  0082
  62    0085      0082
  63    0086      0085  0085
  64    0088      0085
  65    0089      0088  0088
  66    0091      0088
  68    0093      0008
  69    0095      0094  0094
  70    0097      0094
  73    0098      0097  0097
```

```
                                                                                                   PAGE 007
                    *****FORTRAN   CROSS   REFERENCE   LISTING*****
LABEL   DEFINED   REFERENCES
  74    0100      0097
  75    0101      0100  0100
  76    0103      0100
  77    0104      0103  0103
  78    0106      0103
  79    0107      0106  0106
  80    0128      0012  0015  0018  0021  0024  0027  0030  0033  0035  0039  0042  0044  0047  0051  0054  0057  0060
                  0063  0065  0069  0072  0075  0078  0081  0084  0087  0090  0092  0096  0099  0102  0105  0108  0111
                  0114  0117  0120  0122  0126
  82    0109      0106
  83    0110      0109  0109
  84    0112      0109
  85    0113      0112  0112
  86    0115      0112
  87    0116      0115  0115
  88    0118      0115
  89    0119      0118  0118
  90    0121      0118
  92    0123      0008
  93    0125      0124  0124
  94    0127      0124
  95    0129      0128
  96    0130      0128  0128
 101    0011      0010
 102    0013      0010  0010
 521    0068      0067
 522    0070      0067  0067
```

```
                                       /   DBTSYZ /     SIZE OF PROGRAM 000CF4 HEXADECIMAL BYTES PAGE 008

  NAME    TAG   TYPE  ADD.        NAME    TAG   TYPE  ADD.        NAME    TAG   TYPE  ADD.        NAME    TAG   TYPE  ADD.
     X  F       R*4  000384         SY S        R*4  000388         SZ S        R*4  00038C         TH SFA      R*4  0003C0
    XY  FA      R*4  0003C4        KST SF       I*4  0003C8        COS      XF  R*4  000000        SIN      XF  R*4  000000
FRXPR#      XF  R*4  000000       ALOG      XF  R*4  000000     DBTSYZ          R*4  0003CC
```

```
   LABEL   ADDR               LABEL   ADDR               LABEL   ADDR               LABEL   ADDR            PAGE 009

       1  00040A                  2  000412                  3  00041C                  9  000420
      10  000438                101  00046C                102  00048E                 11  00049A
      12  0004BC                 13  0004C8                 14  0004EA                 15  0004F6
      16  000518                 17  000524                 18  000546                 19  000552
      20  000574                 21  000580                 22  0005A2                 23  0005AE
      24  0005D0                 30  0005DC                 31  000610                 32  000632
      33  00063E                 34  000660                 40  000682                 42  0006CC
      41  000700                 39  000722                 43  00072E                 44  000750
      45  00075C                 46  00077E                 47  00078A                 48  0007AC
      49  0007B8                 50  0007DA                 52  0007FC                521  000830
     522  000852                 53  00085E                 54  000880                 55  00088C
      56  0008AE                 57  00088A                 58  0008DC                 59  0008E8
      60  00090A                 61  000916                 62  000938                 63  000944
      64  000966                 65  000972                 66  000994                 68  0009B6
      69  0009EA                 70  000A0C                 73  000A18                 74  000A3A
      75  000A46                 76  000A68                 77  000A74                 78  000A96
      79  000AA2                 82  000AC4                 83  000AD0                 84  000AF2
      85  000AFE                 86  000B20                 87  000B2C                 88  000B4E
      89  000B5A                 90  000B7C                 92  000B9E                 93  000BD2
      94  000BF4                 80  000C12                 95  000C1E                 96  000C26
*OPTIONS IN EFFECT*     NAME=  MAIN,OPT=02,LINECNT=58,SIZE=0000K,

*OPTIONS IN EFFECT*     SOURCE,EBCDIC,NOLIST,DECK,LOAD,MAP,NOEDIT,ID,XREF

*STATISTICS*     SOURCE STATEMENTS =     131 ,PROGRAM SIZE =     3316

*STATISTICS*  NO  DIAGNOSTICS GENERATED

****** END OF COMPILATION ******                                         45K BYTES OF CORE NOT USED

*STATISTICS*  NO  DIAGNOSTICS THIS STEP
```

15.8 Calculation of Fluorine Vapor Pressure

$$p_f = \frac{c_f D P_T}{C_T} ,$$

where

c_f = measured concentration

= 1.84×10^{-5} g moles/l

D = dilution multiplier (see Appendix 15.2)

= 25

P_T = measured system pressure

= 36.33 mm Hg

C_T = total molar concentration in condensed vapor

= 55.42 g moles/l

p_f = 388×10^{-6} mm Hg .